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The Ideal Work-Curve

Cooling Power of the Atmosphere and Comfort during Work

Estimations of Mercury in Hatters' Fur and in Felt

A Study of the Mortality of Coal Miners, England and Wales

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THE IDEAL WORK-CURVE*

THOMAS BEDFORD

Investigator to the Industrial Fatigue Research Board

OBSERVATIONS upon output have been relied upon in a large number of studies directed toward the investigation of industrial fatigue; observers have based their estimates of the physiological results of human activity upon the fluctuations of hourly or daily work-curves. Study of these work-curves points to the probable existence of an ideal work-curve; and, further, it indicates that, should such an ideal curve exist, it would be a straight line showing a slight steady rise from hour to hour and from day to day. Evidence is presented in this article in favor of this proposition, which is of considerable importance in industrial work. Such a curve would indicate that, at the beginning of the day or week, the operative concerned started work very nearly at a maximum rate, and that, as time progressed, practice gradually increased his working capacity; it would demonstrate the existence of a fine adjustment of the operative's working powers to his task with a consequent elimination of undue fatigue. It would render possible, by intensive study of industrial operations, the adjustment of methods, hours, and conditions of work in order to enable this steady maximum of output to be achieved.

The realm of sport affords many examples of the ideal work-curve. The long-distance runner ascertains exactly what is the greatest pace he can maintain lap after lap, and by long training he accustoms himself to this pace. Training for other forms of sport is similar. The chief point is to insure a constant attainment of maximum effort over the whole period of the contest. There must be no spurting in the early part of the race; if the athlete has an extra ounce of energy he must save it for a final spurt. So must it be in industrial work, if the best results are to be obtained.

CURVES DRAWN FROM MASSED DATA

Examination of several typical work-curves for industrial operations discloses support for this contention; Collis and Greenwood (1) have adduced curves

*This article is largely based upon work carried out either by the author or by his colleagues for the Industrial Fatigue Research Board. Received for publication May 19, 1922.

which are of interest. Figure 1A shows a rapid fall from the first hour of each spell of work. This curve represents heavy, monotonous work: the task entailed hard physical exertion unrelieved by any variety of processes. Another curve for a monotonous operation, this one involving no strenuous exertion, is

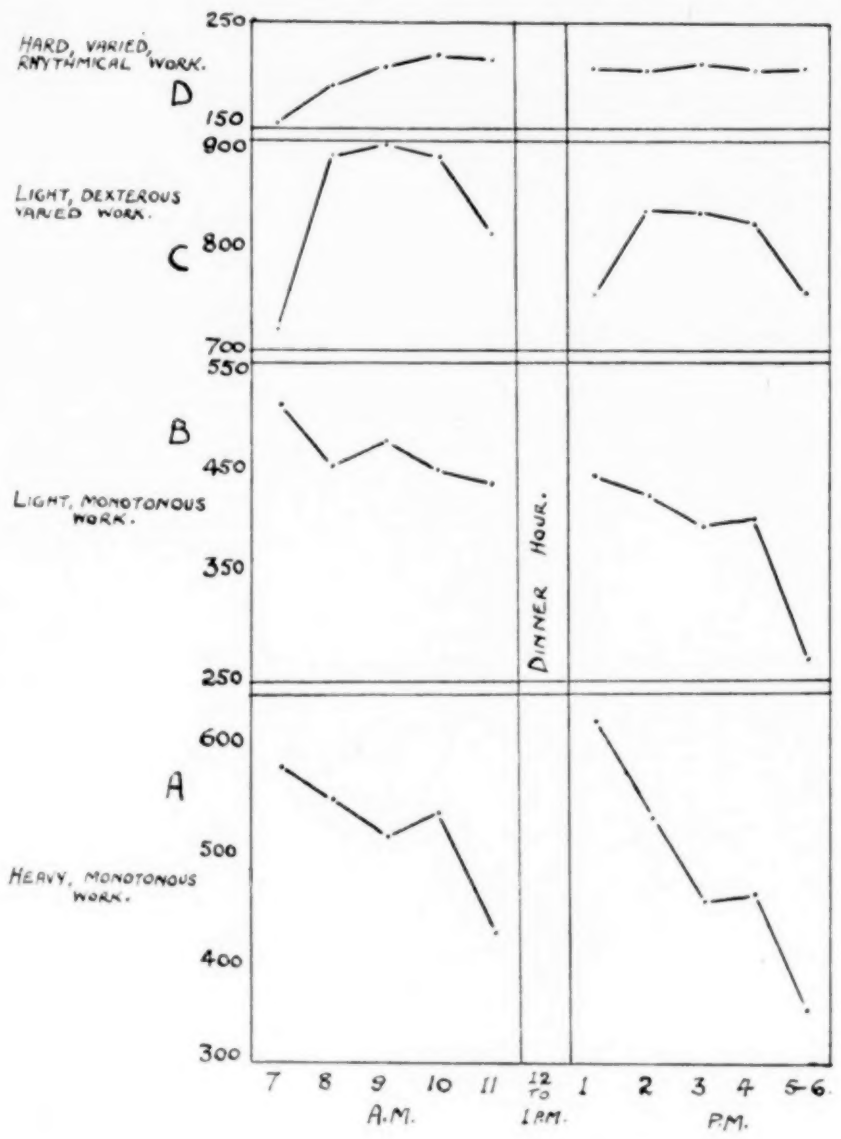

FIG. 1.—Showing typical work-curves in industry.

shown in Figure 1B. Here again we find the steady fall in output, but as the physical work is lighter the fatigue is not so marked. Figure 1C represents work which is light and dexterous, and not monotonous. Here the onset of fatigue is postponed until later in the spell, and the fall in output is not nearly so marked. Figure 1D represents hard, varied, rhythmical work. Although the work was heavy, variety was introduced, and the rhythmic nature of the operation militated against the onset of fatigue, just as is the case in dancing. When variety and rhythm are present we approach our ideal curve.

Another diagram relating to large numbers of workers is reproduced from Vernon's report on British munition factories (2). (See Fig. 2.) The top curve (D) relates to men working fifty-three hours a week at turning and boring 3-inch shells. The work was comparatively light, and the hours not very long, with the result that the work-curve shows a steady rise to Friday. In the remaining curves the work was heavier (when it is considered that, for

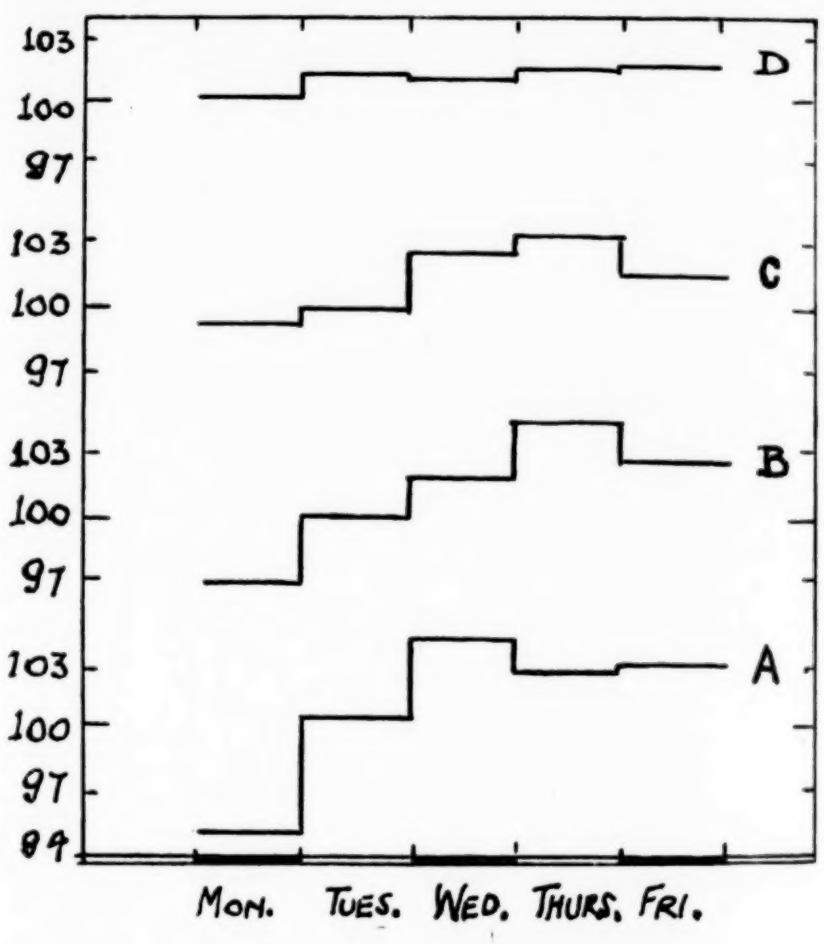

FIG. 2.—Showing comparative work-curves of workers in various factories. A=curve for 140 women working 57.4 hours a week at cartridge-case (rifle) operations; B=curve for 1,000 women working 58½ hours a week at lathe operations, and stamping fuse parts; C=curve for 1,000 men and 300 women working 58½ hours a week at lathe operations, presses for 18-pound cartridge cases, etc.; D=curve for eighty-one men working 53 hours a week at turning and boring 3-inch shells.

the most part, women were concerned), and the hours longer. These curves show a steep rise in the early part of the week and a falling off from Wednesday or Thursday. Apparently the week-end rest did not suffice for full recuperation from fatigue, but practice caused a rise

in output. As the week progressed fatigue overcame the effects of practice, and output fell.

The report on an investigation into the effect of hours of work, carried on under F. S. Lee (3), lends further support to the contention. One diagram, Figure 3, will suffice as illustration. This diagram shows the comparative maintenance of output at two factories, one an eight-hour plant and the other a ten-hour plant. The curve of the eight-hour plant shows a much closer approximation to maximum output than does that of the ten-hour plant, and the ratio of the output in the second spell to that in the first is much higher in the plant where the shorter hours were worked.

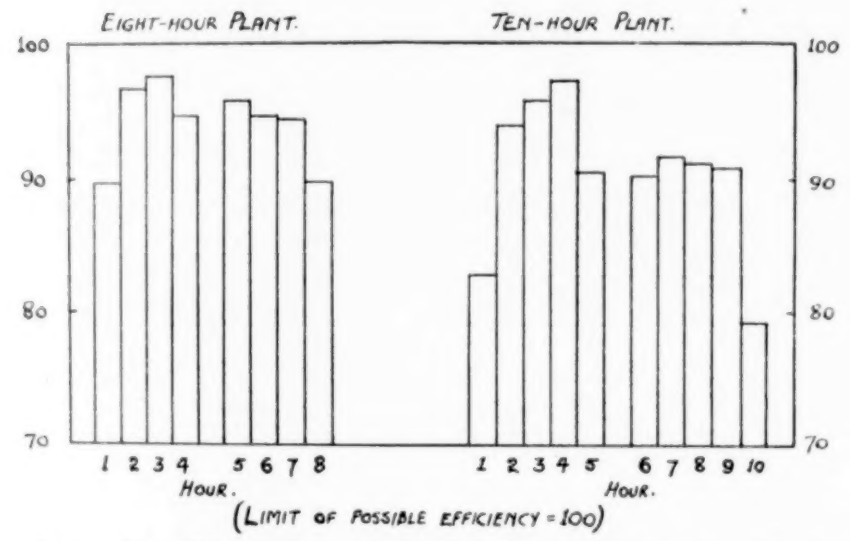

FIG. 3.—Showing comparative outputs of an eight-hour plant and a ten-hour plant.

The foregoing examples show that with greater variety and shorter hours of work there is closer approximation to our ideal curve. These curves, however, do not show the output of single operatives; they refer for the most part to large groups of workers, and in massing data in this way the individual is lost sight of. Grouping tends to smooth out irregularities, and for this reason a study of the output of individual operatives will serve our purpose better than a prolonged examination of figures concerning whole factories or whole departments.

OUTPUT OF INDIVIDUAL OPERATIVES

Previous Observations.—In an investigation in boot and shoe factories, Loveday and Munro (4) found that:

> Where two or more records of output are available for the same operation, the more highly-skilled operative has a more regular graph, and shows less inclination to fall off towards the end of the week than the operative with a lower average output. This phenomenon occurs so frequently that a very irregular graph or serious falling off beginning early in the week will in the very great majority of cases be found to coincide with a low output. Where a workman is comparatively unskilled or ill-suited to his job, his output curve tends to be irregular or to drop as the week passes, whereas the skilled operative, employed on congenial work, shows a curve approaching more nearly to the ideal of a rise throughout the week.

In their report, Loveday and Munro give many diagrams in support of this statement. It will be sufficient for our present purpose to reproduce the first of these charts (Fig. 4), which shows the

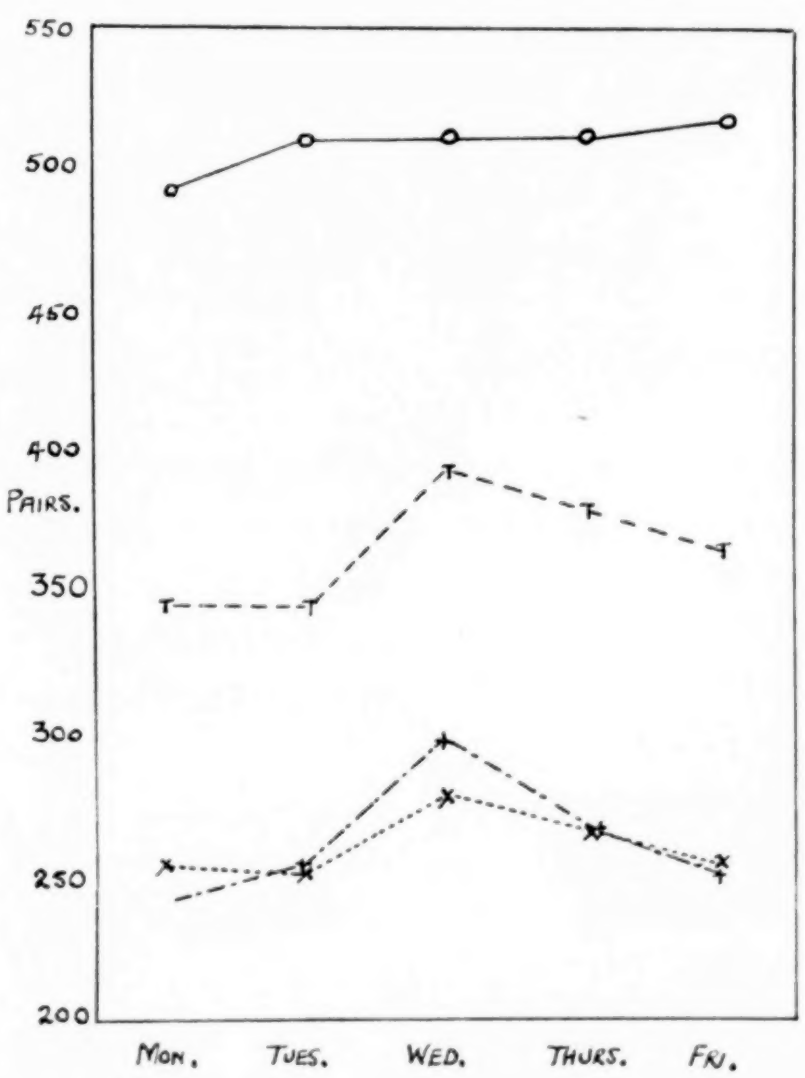

FIG. 4.—Showing actual average daily output of four bottom scourers.

average work-curves of four bottom scourers. The curve of the most highly skilled workman shows a rise throughout the week, while the curves of the other three men reach their highest point on Wednesday and then fall rapidly away. The poorest man of the group shows a slight dip from Monday to Tuesday.

New Observations.—Since the publication of the report by Loveday and Munro, the writer, working for the Industrial Fatigue Research Board, has examined the daily records of output from other boot and shoe factories. These records confirm, to a remarkable extent, the findings of Loveday and Munro; and as the data are hitherto unpublished they are dealt with more fully. In each case the output over a period of twenty to twenty-four weeks was considered. Records for Saturday, on account of the well-recognized influences which affect the output of this half-day, have been omitted; and in some cases, owing to peculiarities in the methods of "booking" work, the figures for Monday or Friday have had to be ignored. Table 1 gives the average output of operatives at Factory A, where the chief product was women's boots.

Heel Scouring.—While the best man reaches his maximum on Wednesday, and the other two on Thursday, the best man has only a slight fall from his maximum and remains almost steady from Thursday to Friday. Of the two men with maximum outputs on Thursday, the poorer man has a slight dip on Wednesday and a steep fall from Thursday to Friday, while the better man shows a rise in output to Thursday and a much slighter fall to Friday.

Heel Trimming.—Only one man's record was obtained. He is recognized as a highly-skilled worker—the best for his operation in the factory—and his output shows a Thursday maximum. The level of his output varies but very slightly, the mean variation of the daily averages being only 0.2 per cent. of his average output.

Bottom Scouring.—The better man has his maximum on Wednesday, the poorer man, on Thursday; but the better man's fall to Thursday is only 0.2 per cent., and his curve is more regular than that of the poorer man. The output of the latter falls much more steeply from Thursday to Friday.

Seat Wheeling.—The best man in this group reaches his maximum on Thursday, the second on Tuesday, and the third on Thursday. The fourth man, whose output is by far the lowest, shows practically a straight line curve. This last man is about 70 years of age, and his unusually regular curve is probably due to his having adopted some limitation of output as a measure of self-protection.

Edge Setting.—The best man has a definite maximum on Wednesday, the second on Tuesday, and the third on Monday. The fourth man's output reaches a maximum on Tuesday, but the rise from Monday to Tuesday is only slight. Monday is the best day for the fifth man. The sixth has a maximum on Wednesday, and then falls away. The seventh man has a very erratic curve; his output reaches a maximum on Tuesday.

Pulling Over.—All three men have a maximum on Wednesday. The worst man has the steepest fall from Wednesday to Thursday.

Consolidated Lasting.—These men reach their maximum on Wednesday, and their curves are practically the same. Men on this operation work as a team, hence the similarity in their outputs.

Knocking Up (*Pounding Up*).—The best of these three men has his highest output on Wednesday; the other two, on Tuesday. The best man has the most even output. Of the two worst men, the better recovers on Thursday, while the other continues to fall away.

Getting Off.—The first man has his best day on Thursday. Although the second man has his maximum on Monday he has almost the same output on Thursday; his curve is almost a straight line. The third man shows a steady rise to Thursday; the fourth falls from Wednesday to Thursday. The two best men have the straightest curves, while the curve of the worst man is the most erratic.

Averages of daily output for operatives at Factory B are given in Table 2. At this factory, Saturday's and Monday's outputs are grouped together in the company's books, hence the output from Tuesday to Friday only is considered.

Heel Scouring. — Both men have their highest output on Tuesday, but the better man recovers to a greater extent on Thursday than does the other man.

Edge Trimming. — In this operation both men reach their maximum on Wednesday. The better man has the more variable curve, but his greater variability is probably due to the fact that this man, though a highly-skilled worker, is in a poor state of health and is notably a bad timekeeper.

Getting Ready.—The best man of this group reaches his maximum on Friday, the second man on Thursday, and the third on Tuesday. The worst man reaches his acme on Thursday, but his output falls steeply from Tuesday to Wednesday, and more steeply from Thursday to Friday: his curve is very erratic.

TABLE 1.—SHOWING ACTUAL AVERAGE DAILY OUTPUT FOR OPERATIVES AT FACTORY A

Operation	Operatives in Order of Merit	Whole Period	Average Daily Output in Pairs for Monday	Tuesday	Wednesday	Thursday	Friday
Heel scouring	1	575.2	580.3	574.0	*582.2*	570.4	569.3
	2	512.6	511.2	508.9	515.2	*519.4*	508.3
	3	492.9	485.4	499.3	495.0	*501.9*	482.7
Heel trimming	1	934.2	933.7	932.7	934.9	*938.2*	931.4
Bottom scouring	1	636.9	627.0	645.1	*650.2*	649.0	613.1
	2	572.5	558.8	580.4	586.6	*596.7*	540.0
Seat wheeling	1	573.4	581.3	575.0	575.0	*586.3*	549.4
	2	543.8	529.7	*565.1*	542.6	543.3	538.3
	3	539.4	523.6	541.0	546.4	549.3	536.7
	4	380.9	374.7	383.4	383.3	379.3	*383.6*
Edge setting	1	181.7	179.1	182.5	*186.0*	181.3	179.6
	2	181.3	179.3	*183.9*	182.8	181.5	178.9
	3	177.1	*182.5*	178.5	175.1	177.4	172.0
	4	176.7	178.9	*179.6*	175.5	174.0	175.3
	5	175.7	*178.0*	176.3	174.9	175.4	174.1
	6	174.3	175.9	174.0	*176.8*	174.6	170.1
	7	173.5	173.9	*179.0*	170.6	175.9	168.0
Pulling over	1	444.3	435.2	447.3	*449.0*	445.8	—
	2	417.2	410.1	419.0	*421.1*	418.5	—
	3	382.5	379.4	380.7	*388.9*	380.9	—
Consolidated lasting	1	192.1	187.5	192.5	*195.4*	193.1	—
	2	191.6	187.2	193.3	*194.7*	192.1	—
	3	191.6	187.5	192.6	*193.4*	193.1	—
Knocking up (Pounding up)	1	678.2	667.6	667.8	*698.8*	668.5	—
	2	661.8	645.0	*676.9*	654.7	670.5	—
	3	635.7	621.8	*648.0*	643.1	630.0	—
Getting off	1	398.9	399.0	400.4	392.6	*403.7*	—
	2	370.8	*371.6*	369.4	370.7	371.4	—
	3	343.2	339.5	340.0	345.0	*348.2*	—
	4	215.6	213.4	211.8	*223.4*	213.7	—

Edge Setting.—Here the two best men have their maximum outputs on Wednesday. The better of these has the slighter fall from Wednesday, and his fall is checked on Friday; while the worse man shows a steep fall. The third man reaches his maximum on Thursday, and his curve is the steadiest. He is recognized as a steady worker who takes life easily, and it is practically certain that he does not work to his full capacity.

TABLE 2.—SHOWING ACTUAL AVERAGE DAILY OUTPUT FOR OPERATIVES AT FACTORY B

Operation	Operatives in Order of Merit	Whole Period [1]	Average Daily Output in Pairs for Tuesday	Wednesday	Thursday	Friday
Heel scouring	1	186.8	*192.1*	186.1	191.1	178.1
	2	125.6	*133.8*	125.0	126.8	116.8
Edge trimming	1	381.6	371.8	*409.2*	377.8	367.7
	2	266.9	257.7	*273.6*	268.1	268.3
Getting ready	1	156.7	155.7	155.2	157.0	*158.7*
	2	150.5	150.8	149.5	*151.3*	150.4
	3	119.5	*120.9*	119.6	118.0	119.4
	4	96.0	99.3	92.8	*100.0*	92.0
Edge setters	1	199.8	195.6	*209.2*	197.8	196.5
	2	189.3	190.6	*207.0*	191.7	167.8
	3	174.9	175.6	175.4	*178.7*	170.0

[1] It was impossible to secure the output for Monday owing to the fact that Monday's and Saturday's outputs were grouped together in the company's records.

Distribution of Output

The figures just examined show the average values for each day of the week. They show clearly that in almost every case the best workman has the most regular average curve, and that this curve approaches most nearly to the ideal of a steady rise throughout the week. The question arises whether the most skilled man is actually the most consistent worker if, instead of averages, the output of individual days is taken. This point may be tested by arranging each man's record in the form of a frequency distribution. Generally the best worker is found to have his output values more closely grouped about the mode (or most usual figure) than have his fellow-workmen. The frequency polygons shown in Figures 5 to 10 illustrate this point. Not all the men's records are illustrated in this way, but with only one or two exceptions this phenomenon holds good.

It seems, then, that whether we consider the average daily values or the

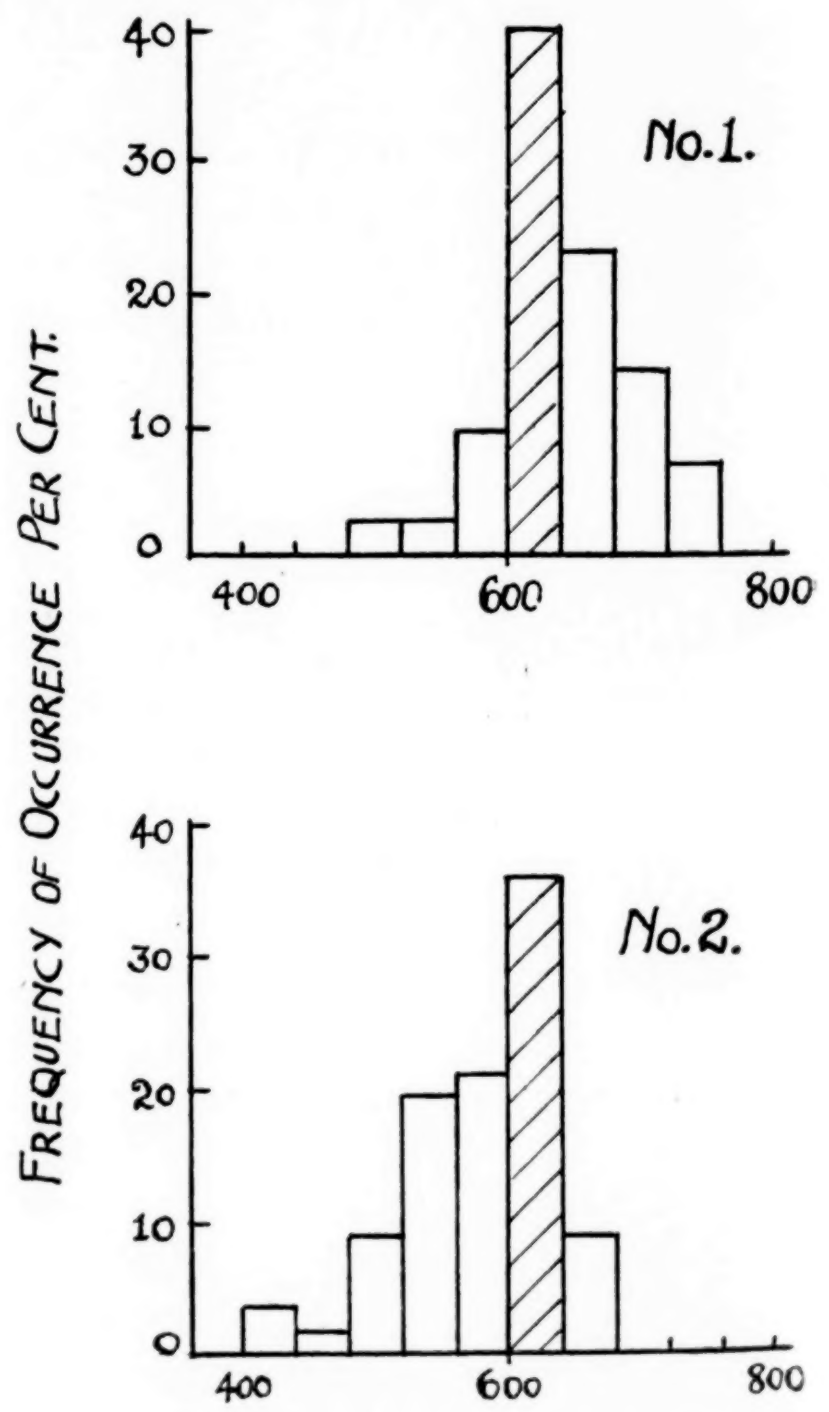

FIG. 5.—Showing output, in pairs, of two bottom scourers at Factory A.

frequency distributions of output, we find that the unskilled worker is more erratic than his more highly-skilled workmate.

Another interesting point is brought out in the frequency polygons shown in Figures 5 to 10. In several instances men on the same operation show similar modal values, but the better man has more observations falling above the mode, and fewer below it, than has the poorer man. Figures 5 and 6 clearly illustrate this point in the case of bottom

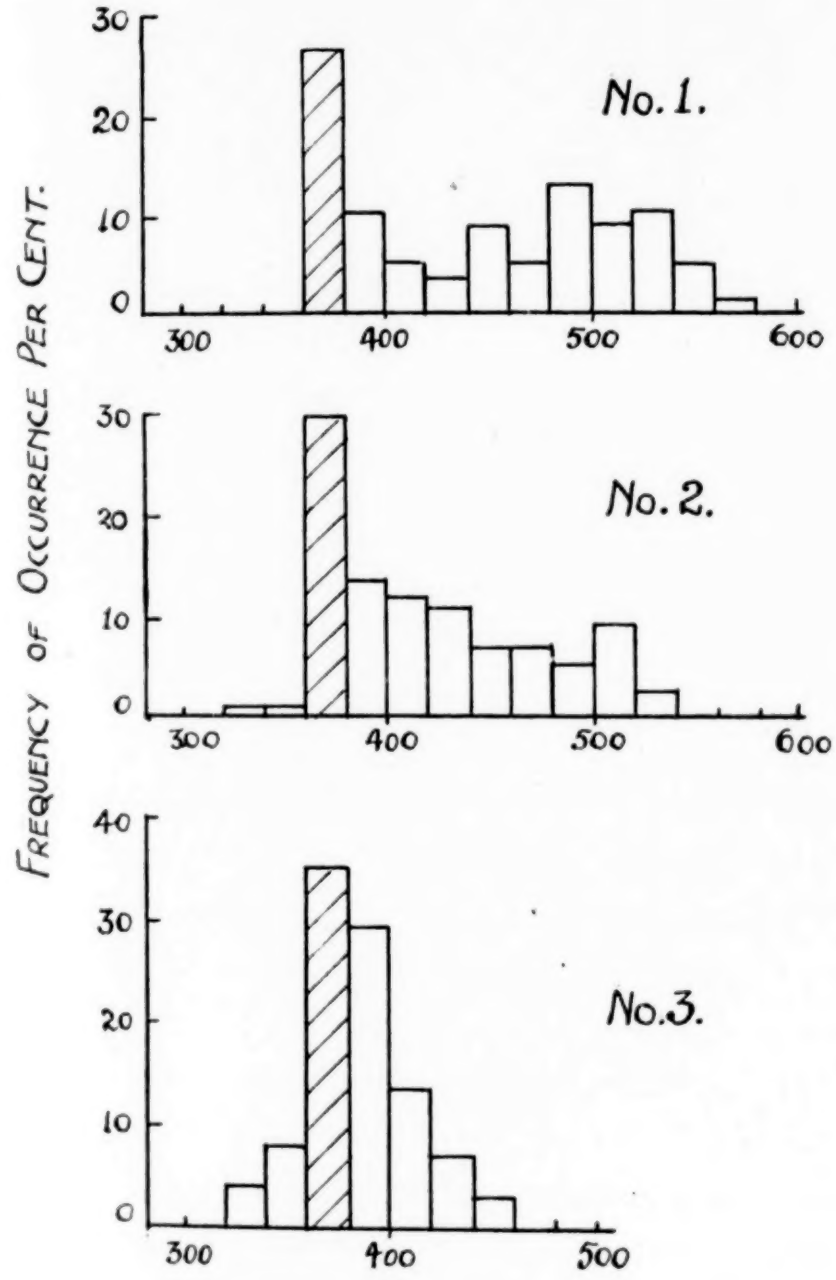

Fig. 6.—Showing output, in pairs, of three pullers over at Factory A.

scourers and pullers over at Factory A. In the group of four getters off (Fig. 7) it is again noticeable. Operative No. 1 does not entirely agree, but the other three men of the group show a markedly frequent occurrence of output of from 320 to 340 pairs a day. Operative No. 4, whose output level is very low, has a noticeable frequency at this figure. At Factory B the three edge setters (Fig. 8) show a well-defined frequency of output of from 190 to 200 pairs per day, and the best man has an output of over 200 more frequently than the others. There is a very considerable difference between

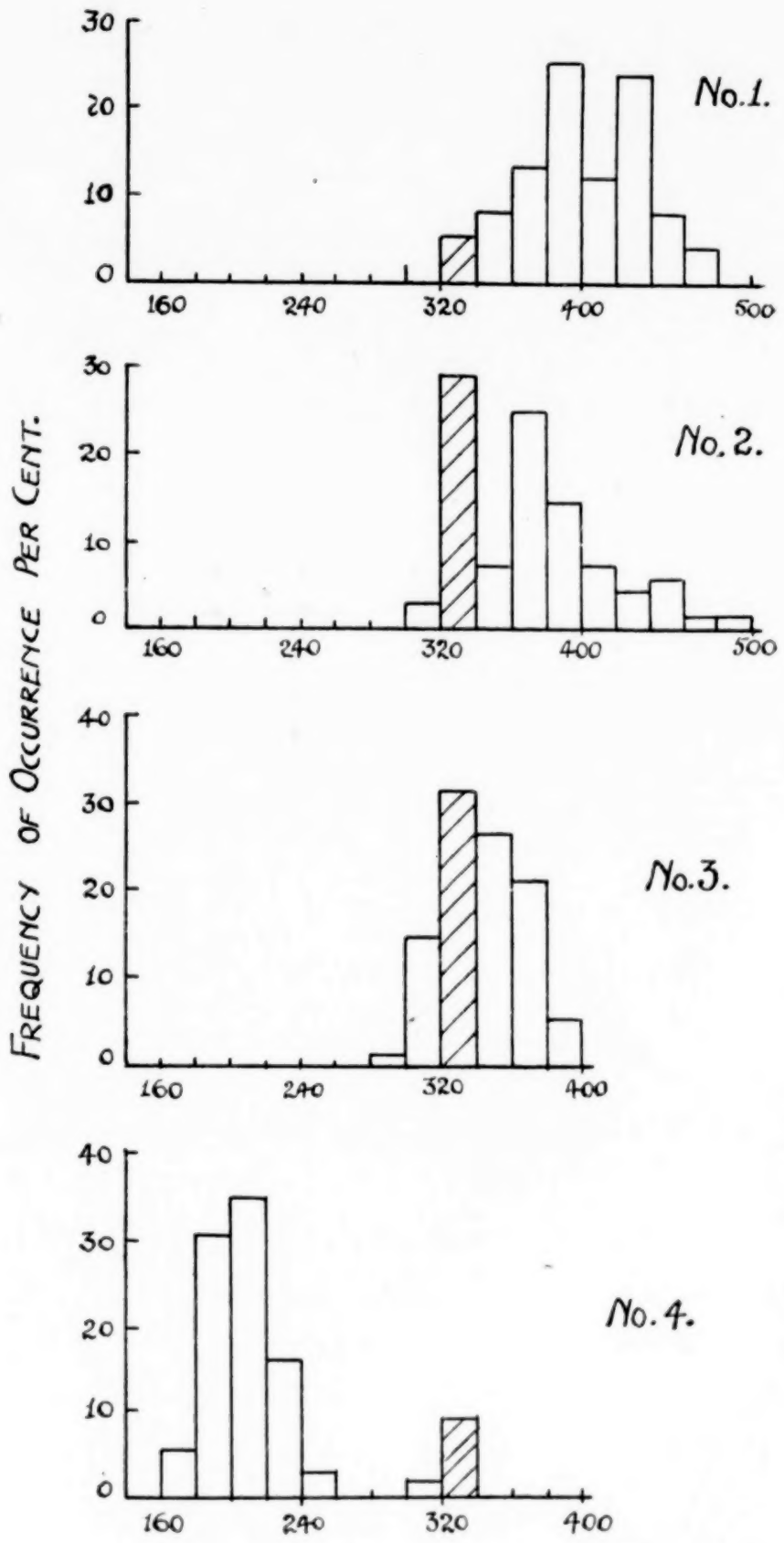

Fig. 7.—Showing output, in pairs, of four getters off at Factory A.

the efficiencies of the two heel scourers at Factory B; the better man averages three pairs to the other man's two pairs, yet their frequency distributions (Fig.

9) show a tendency toward an outpnt of about 150 pairs. A somewhat similar diagram is shown in the case of the two edge trimmers.

At both factories payment is by a supplementary piece rate, that is, any output above the standard for the operation is paid for at a uniform piece rate. The similar modes in the frequency distributions, therefore, are

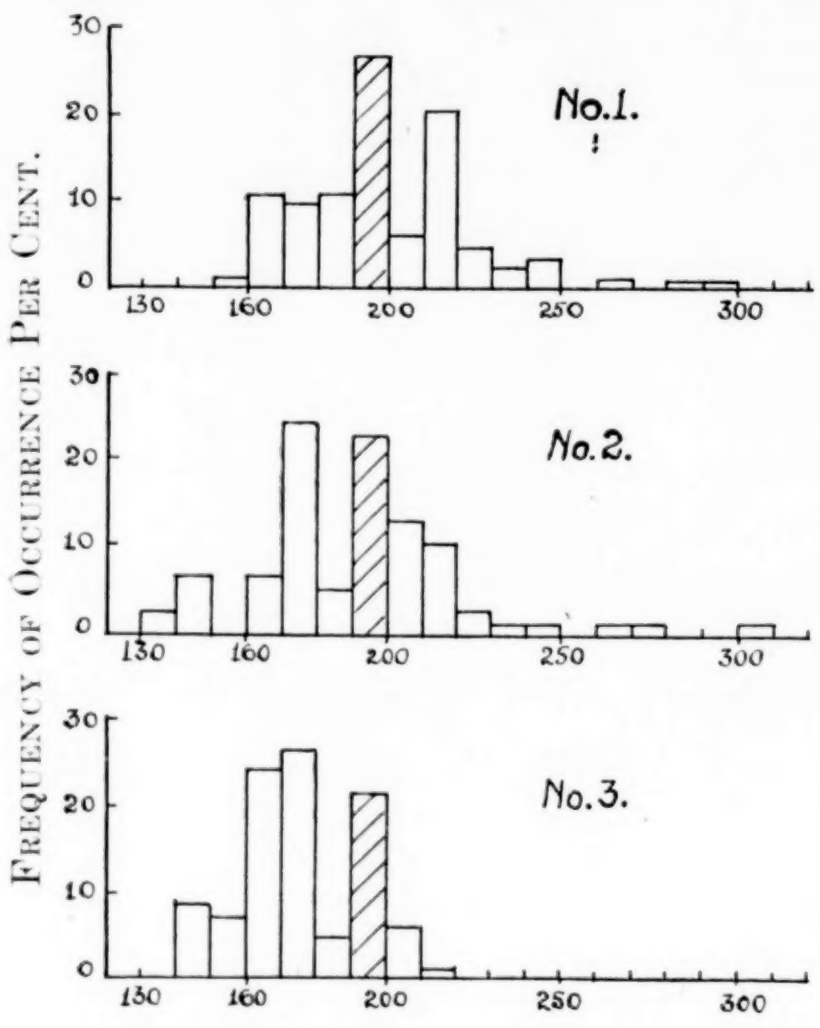

FIG. 8.—Showing output, in pairs, of three edge setters at Factory B.

clearly not due to the operation of any premium bonus. There appears to be some understanding as to what constitutes a good day's work, and the highly-skilled worker often exceeds this figure, and rarely falls below it. On the other hand, the operative whose skill is less strives to attain this figure and fails to reach it more often than he exceeds it. This constant effort on the part of the less-skilled worker may account for the earlier decline of his average weekly curve.

OTHER EXAMPLES OF OUTPUT

An interesting example is afforded in a report on "Motion Study in Metal Polishing" by Farmer and Brooke (5). Certain girls were employed "roughing" spoons, an operation which required them to stand at their machines all day. The process of glazing was introduced to assist the "roughers," and

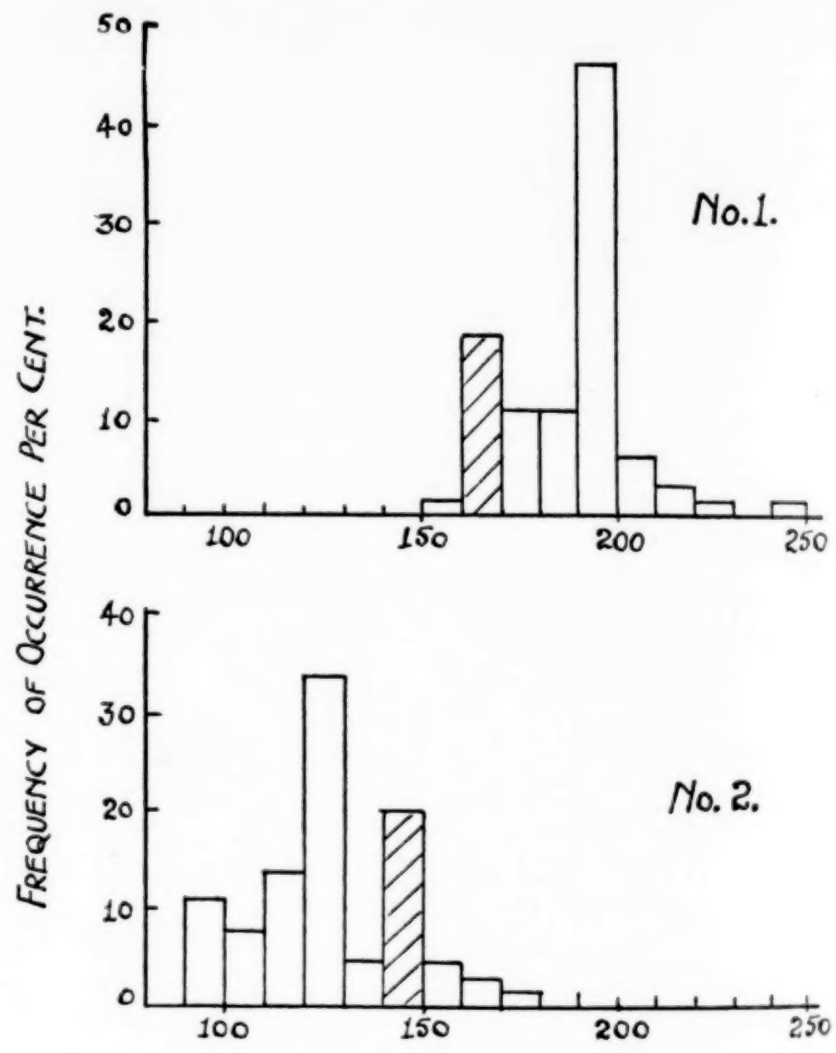

FIG. 9.—Showing output, in pairs, of two heel scourers at Factory B.

at this operation the girls were enabled to sit. The output of one girl is given in Tables 3 and 4. Observations were made continuously for two days. On the first day the girl was engaged in roughing tablespoons without glazing, and on the second day she glazed the edges of the spoons before roughing them. The tables give the actual time taken; all unproductive time, such as that taken for rests or for getting fresh work, is omitted.

On the second day when the edges were glazed the girl's output was actually increased by eight spoons. On the first day she took twenty minutes longer to rough the last three dozen spoons than to rough the first three dozen; but on the second day her time for roughing was only eight minutes longer at night than in the morning. The investigators concluded that "there is

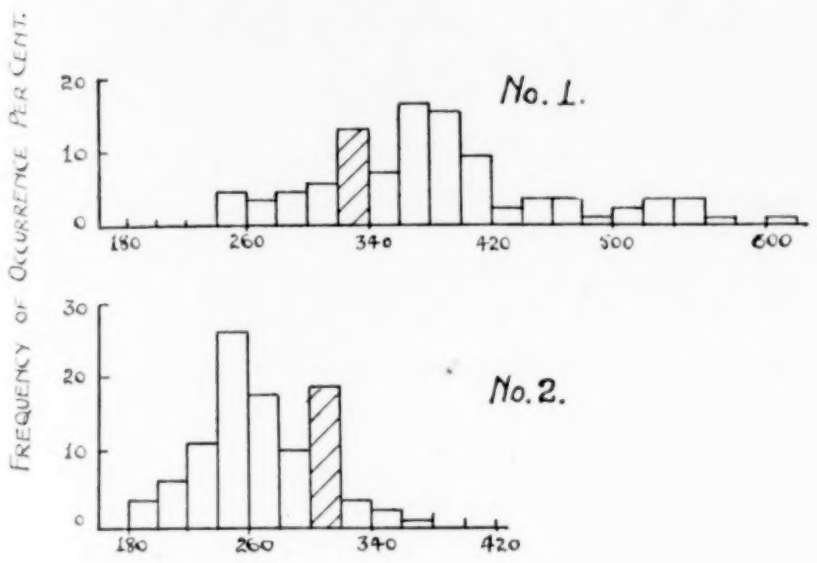

FIG. 10.—Showing output, in pairs, of two edge trimmers at Factory B.

a strong probability that the introduction of glazing diminishes the fatigue of the worker by enabling her to sit at her work for certain periods during the day." This diminution of fatigue is accompanied by a nearer approximation of the work-curve to the ideal, as will be seen from a comparison of the roughing times in Tables 3 and 4.

Another instance may be quoted from the same report. The output of an "outside grease dollier" was ascertained when she worked standing and when a comfortable seat was provided. In this case the investigators found that:

1. The output when the worker is seated is higher than when she is standing. Thus the average half-hourly output throughout the day is 18.1 units when sitting and 16.3 units when standing.
2. Although the fluctuations in her output curve when she is seated are greater than when she is standing, yet there seems to be more buoyancy in the former case. Thus in the morning the curve representing work sitting constantly reaches the standard of the first hour's work, and although it drops below it in the afternoon, yet it exceeds it in one spurt at 4 o'clock. On the other hand, the curve representing work standing, except for two spurts at 12 o'clock and 4 o'clock, never touches the standard reached during the first hour's work of the morning.

TABLE 3.—OUTPUT OF WORKER 15

(*Roughing Only*)

Spoons	Rate of Work (Minutes per 3 Dozen)	Hour Completed
First 3 dozen.....	100½	10.47 A.M.
Second 3 dozen.....	119½	2.03 P.M.
Third 3 dozen.....	98½	4.19 P.M.
Last 16	126½	5.25 P.M.
124	Av. 108	

TABLE 4.—OUTPUT OF WORKER 15

(*Glazing and Roughing*)

Spoons	Rate of Work (Minutes per 3 Dozen) Glazing	Roughing	Total	Hour Completed
First 20....	32½	77½	110	9.17 A.M.
First 3 dozen	20	80	100	11.31 A.M.
Second 3 doz.	29	77	106	2.43 P.M.
Third 3 doz.	33	85½	118½	5.09½ P.M.
Last 4	—	—	—	
132	Av. 28	Av. 80½	Av. 108½	

An investigation now being carried on by Dr. H. M. Vernon and the writer is affording somewhat similar results. The output of a group of girls engaged in labelling small packets shows that, on the whole, the quickest workers approach most nearly to a rise throughout the day. The slowest workers show a greater fall in output as the day progresses.

No reference has so far been made to the influence which social habits may exert on the work-curve; one influence must, however, be noted—namely, the

use of alcohol. Stehr (6) has pointed out that the more a workman indulges in immoderate use of alcohol during the week-end, the more his work-curve shows a steady upward direction in the course of the week. This result Stehr ascribes to the disappearance of intoxication. Although the curve of such a workman tends to rise as the week advances, yet it rises much more steeply than does the ideal curve; this phenomenon is shown graphically in Figure 11

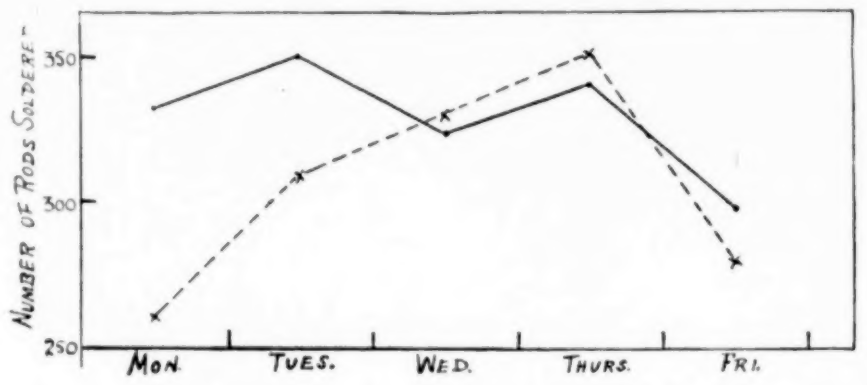

FIG. 11.—Showing comparative work-curves of two solderers in a Cologne umbrella factory. Unbroken line=steady man; broken line=man easily persuaded to drink.

drawn from records given by Stehr. The records upon which it is based are averaged on the output of four weeks at the monotonous process of soldering iron rods over a coal fire—work which required no particular intelligence or manual dexterity. There should generally be no difficulty in distinguishing the steeply rising work-curve of a week-end drinker from the gentle ascent of the ideal work-curve.

SUMMARY

Examples have been given which show that:

1. Where there was a variety of work and the operation was of a rhythmic nature, a rapid fall in output was avoided and the work-curve remained steady with a tendency to rise throughout the day.

2. When the hours of work were shorter and work lighter, the output rose throughout the week; while with longer hours and heavier work the output curves were increasingly irregular with a rapid falling off toward the week-end.

3. At a factory with an eight-hour day there was a closer approximation to an even maximum output than at a factory with a ten-hour day.

4. Individual output records show that in boot and shoe factories, in practically every group of workers considered, the best worker of a group had a graph rising toward the end of the week, while the poorer workman's curve fell earlier in the week and was more irregular. Consideration of frequency distributions reveals the fact that the better worker was consistently steadier than his fellow-workmen.

5. In a group of girls labelling small packets, the quickest worker was generally the steadiest.

6. Other examples show that where fatigue was lessened by the provision of sitting accommodation, output was higher, and the work-curve came nearer to our ideal of a rise throughout the day.

CONCLUSION

While each of these examples in itself may be of little significance, each lends support to the others. Especially remarkable are the hitherto unpublished boot and shoe data; in almost every group of workers the same connection between efficiency and steadiness was found. The work-curves of the best workers and of those employed under the best conditions almost invariably tended toward a steady rise throughout the day and throughout the week. The definition of the ideal work-curve given at the beginning of this paper seems to have been amply justified.

If human effort in industry is to be used to the best advantage, steadiness at work must be encouraged and useless spurting at the beginning of the day must cease. As Farmer (7) says, "The fast stroke does not always win a rowing race; far more often the slow stroke is more effective, and, generally, such a system is more effective because it is slow and allows for plenty of time to recuperate between each effort. So it must also be in industry."

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COOLING POWER OF THE ATMOSPHERE AND COMFORT DURING WORK*

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INTRODUCTION

ONE of us (L. H., 1) has pointed out that more care should be taken to arrange atmospheric conditions in factories, etc., to suit the nature of the work being done. The heavier the work, the higher will be the cooling power of the atmosphere required to maintain comfort. Observations made in many workshops where vigorous muscular work was done showed that the cooling power of the atmosphere as measured by Hill's kata-thermometer was far too low, and that sweating and discomfort were inevitable. In these workshops no one seemed interested in the matter and no one was sufficiently skilled to regulate the ventilation in order to produce a suitable cooling power.

In the present paper we endeavor to prove from physiological experiments that there are fundamental reasons why more attention should be paid to these matters. From what has already been published by workers on respiratory exchange and metabolism during muscular work, it seems to us that no great attention has been paid by them to the effects of unsuitable atmospheric and bodily conditions. Their experiments have nearly all been carried out with the subject very lightly clothed, and not under such ill-ventilated conditions as are often met in workshops where workers, in many cases, wear their usual clothes.

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METHODS

Most of our experiments were carried out on a trained subject, C. P., who has been employed in such experiments for nearly two years. Many experiments were done with ourselves as subjects, with results very similar to those for our subject C. P. Only short periods of work are considered here.

For respiratory exchange we used the Douglas-Haldane method as recommended by Cathcart (2). For observations on resting metabolism a ten-minute sample was usually taken, while during work at a controlled rate and lift of weight, a three-minute sample was found to be sufficient. The sample was collected during the last three minutes of work, care being taken that the general conditions were not affected by the collection. Duplicate analyses were made of every sample of expired air, the average result being used for the calculation. Readings from wet and dry bulb thermometers, from wet and dry kata-thermometers, from axillary and cheek temperatures and the rate of pulse were recorded. The pulse was counted both while the subject was at work and immediately after he stopped work.

To obtain various kata-thermometer cooling powers we used three rooms: an ordinary laboratory room with a gas fire and well ventilated by windows opened enough for comfort during sedentary work—that is, with a dry kata-thermometer cooling power of about 6 to 7 milli-

calories per square centimeter per second; a warm, stagnant room with a dry kata-thermometer cooling power varying from 3.9 to 5 millicalories per square centimeter per second; and a long, narrow, closed passage fitted up as a wind tunnel with a large fan at one end which could be driven at various rates to produce winds of various speeds; as this tunnel was out of doors and not artificially heated, the cooling power during our experiments in winter was about 10 millicalories per square centimeter per second with the fan at rest, and of course much higher—about 25—if the fan was used.

From the results given in the tables it will be observed that we have expressed the body heat production in millicalories per square centimeter per second, as this is the method of expressing heat loss as measured by the kata-thermometer. The body heat production is also expressed in terms of calories *per diem*. The observations were made a few hours after a light meal, consisting mainly of carbohydrate.

Cooling Power and Efficiency

The results of the experiments performed in order to determine the effect of cooling power on efficiency are given in Table 1. In determining the efficiency we have followed fairly closely the methods of Benedict and Cathcart (3). The terms "gross efficiency" and "net efficiency" are employed by us with their usual meaning. Thus, gross efficiency means the number of calories, used up by the external work, expressed as percentage of the total calories found; while net efficiency means the number of calories, used up by the external work, expressed as percentage of the total calories minus the metabolism while the subject is sitting at rest on the ergometer. The efficiency designated "E" on Table 1 was obtained by using the total calories found and the total kilogrammeters of work performed in each experiment marked B as the basal figures for each experiment marked C; in each experiment B, a smaller amount of work was performed than in each experiment C. We have taken the usual standard figures 0.00234 Calories as representing the heat used in the performance of 1 kilogrammeter of external work. In all experiments B and C shown in Table 1, the rate of pedalling was about seventy revolutions per minute, this rate being the most suitable, as pointed out by Benedict and Cathcart (3). In each experiment B, the subject worked against a pressure of 2 kg., and in each experiment C against a pressure of 2.5 kg., Schuster's (4) modification of Martin's bicycle ergometer being employed.

From Table 1, it will be seen that we carried out experiments with dry kata cooling powers varying from 3.9 in the warm room to 11.2 in the cool tunnel, with practically no change in the muscular efficiency for the work performed. Thus, in experiment 3B under a cooling power 3.9, we found that the gross efficiency was 15.1 and the net efficiency 18.4; while in experiment 7B under a cooling power 11.2, that is, nearly three times as great, we found practically the same figures for the efficiencies—namely, 14.8 and 18.5, respectively—so that within this great range of cooling power and under the conditions of experiment specified, cooling power had no effect on muscular efficiency. We shall later endeavor to show that with regard to pulse rate and comfort the higher cooling powers possessed great advantage over the lower cooling powers.

In experiment 6A, the subject sat for half an hour in a hot room at 35.5°C.

TABLE 1.—COOLING POWER AND EFFICIENCY

	No. of Experiment	Date[2]	Time	Kata-Thermometer Cooling Power		Temperature		Check Temperature	Axillary Temperature	Pulse Rate	Respiratory Quotient	Calories per Diem	Kilogrammeters per Min.	Kilogrammeters Total
				Dry	Wet	Dry Bulb	Wet Bulb							
				millicalories per sq. cm. per second		°C	°C	°C	°F					
WARM ROOM EXPERIMENTS	1A	4–3–22	11:00-11:35	5.0	15.3	19.5	14.5	34.6	98.2	84	0.812	1760	—	—
	1B	" " "	11:35-11:50	"	"	"	"	35.5	98.0	132	0.936	8580	408	6080
	1C	" " "	11:56-12:10¾	"	"	"	"	35.8	97.8	156	0.967	10550	507	7425
	2A	4–5–22	11:00-11:36	4.2	13.6	22.6	15.3	34.2	96.8	84	0.796	1930	—	—
	2B	" " "	11:36-11:51	"	"	"	"	35.6	94.0	110	0.947	8520	391	5860
	2C	" " "	12:03-12:20	"	"	"	"	35.1	96.5	140	0.977	10100	494	8400
	3A	4–6–22	11:15-11:53	3.9	13.5	22.5	17.0	34.9	97.6	78	0.811	1695	—	—
	3B	" " "	11:53-12:08	"	"	"	"	35.5	97.6	120	0.896	9280	414	6220
	3C	" " "	12:18-12:37	"	"	"	"	35.5	98.8	130	—	—	524	9950
TUNNEL EXPERIMENTS	4A	3-29-22	10:50-11:24	10.3	24.4	6.0	4.0	27.5	96.8	72	0.763	1795	—	—
	4B	" " "	11:26-11:43	"	"	"	"	28.0	98.0	108	0.923	8070	406	6900
	4C	" " "	11:50-12:04	"	"	"	"	31.7	98.0	120	0.927	11000	509	7125
	5A	3-30-22	10:55-11:28	10.8	25.3	5.0	3.0	26.7	98.0	72	0.843	1825	—	—
	5B	" " "	11:33-11:51	"	"	"	"	28.0	98.0	108	0.863	8790	407	7320
	5C	" " "	12:00-12:15	"	"	"	"	30.9	98.0	120	0.862	10250	515	7725
	6A	3-31-22	11:10-11:47	0.0	10.1	35.5	22.2	36.6	98.0	78	—	—	—	—
	6B	" " "	12:03-12:19	10.9	22.5	5.0	3.0	31.6	97.4	104	0.926	8640	399	5990
	6C	" " "	12:25-12:40	"	"	"	"	32.2	97.8	125	0.879	9760	507	7600
	7A	4–4–22	11:00-11:32	11.2	26.8	5.5	4.0	27.5	94.0	71	0.906	1755	—	—
	7B	" " "	11:47-12:02	"	"	"	"	28.5	94.0	108	0.926	9280	407	6100
	7C	" " "	12:08-12:42	"	"	"	"	33.5	96.8	144	0.941	10900	503	17100
MIDNIGHT EXPERIMENTS IN LABORATORY	8A	4-10-22	11:30-12:15	6.3	19.7	16.0	11.0	31.7	97.0	69	0.771	1570	—	—
	8B	" " "	12:15-12:30	"	"	"	"	33.6	97.0	108	0.873	8640	415	6220
	8C	" " "	12:37-12:52	"	"	"	"	34.0	97.4	125	0.897	10250	510	7650
	9A	4-11-22	12:00-12:35	5.7	18.5	17.5	12.5	32.3	97.0	72	0.794	1450	—	—
	9B	" " "	12:38-12:53	"	"	"	"	34.0	97.0	105	0.930	8585	416	6240
	9C	" " "	1:00- 1:15	"	"	"	"	34.5	97.2	132	0.954	10450	523	7850

[1]Height of subject=161.2 cm.; weight=58 kg.

DURING EXPERIMENTS WITH SUBJECT C. P.[1]

Body Heat Production	Respiration	Efficiency			Remarks
		Gross	Net	"E"	
millicalories per sq. cm. per second	*l. per minute*	%	%	%	
1.29	5.7	—	—	—	At rest, on ergometer; ordinary clothing; comfortable.
6.28	22.5	15.9	20.0	—	Working on ergometer; ordinary clothing; comfortable.
7.72	29.4	16.1	19.3	20.9	Working on ergometer; ordinary clothing; very hot and uncomfortable, perspiring freely.
1.41	6.2	—	—	—	At rest, on ergometer; ordinary clothing; comfortable; some movement.
6.24	24.5	15.5	20.0	—	Working on ergometer; stripped to waist; comfortable.
7.41	28.6	16.5	20.3	22.1	Working on ergometer; stripped to waist; very hot and uncomfortable, perspiring.
1.24	5.7	—	—	—	At rest, on ergometer; ordinary clothing; comfortable.
6.80	25.4	15.1	18.4	—	Working on ergometer; ordinary clothing; warm.
—	—	—	—	—	Working on ergometer; ordinary clothing. At 12:27, when pulse reached 144, oxygen was administered until 12:37, greatly relieving respiration and reducing pulse to 130; uncomfortably hot and perspiring.
1.31	5.9	—	—	—	At rest, on ergometer; ordinary clothing; comfortable.
5.91	20.9	16.9	21.6	—	Working on ergometer; ordinary clothing; comfortable.
8.00	29.4	15.6	18.5	11.7	Working on ergometer; ordinary clothing; perspiring slightly.
1.33	6.1	—	—	—	At rest, on ergometer; ordinary clothing; comfortable.
6.44	22.1	15.6	19.6	—	Working on ergometer; ordinary clothing; comfortable.
7.51	26.1	16.9	20.0	24.8	Working on ergometer; ordinary clothing; warm.
—	—	—	—	—	Sitting in hot room; ordinary clothing; perspiring slightly.
6.34	22.8	15.6	—	—	Working on ergometer; ordinary clothing; comfortable.
7.15	25.3	16.7	—	27.8	Working on ergometer; ordinary clothing; fairly comfortable.
1.28	5.8	—	—	—	At rest, on ergometer; ordinary clothing; felt cold.
6.80	24.5	14.8	18.5	—	Working on ergometer; ordinary clothing; comfortable.
7.96	29.0	15.6	18.6	19.8	Working on ergometer; ordinary clothing; felt more comfortable than when working in hot room at same rate for half the time. (See Experiment 1C.)
1.15	5.1	—	—	—	At rest, on ergometer; ordinary clothing; rather sleepy.
6.33	22.7	16.1	19.7	—	Working on ergometer; ordinary clothing; rather sleepy.
7.51	26.6	16.7	19.8	20.0	Working on ergometer; ordinary clothing; rather sleepy; perspiring slightly.
1.06	4.8	—	—	—	At rest, on ergometer; ordinary clothing; rather sleepy.
6.28	22.6	16.4	19.7	—	Working on ergometer; ordinary clothing; rather sleepy.
7.66	29.6	16.8	19.7	19.5	Working on ergometer; ordinary clothing; rather sleepy; perspiring slightly.

[1]Arrangement of dates follows the American custom—*i.e.*, month, day of month, year.

just before working in the cool tunnel, in order to see whether previous exposure in such a hot room would affect the efficiency. It will be observed that no marked difference was obtained under such conditions; the efficiencies in experiments 6B and 6C should be compared with those for other experiments marked B and C respectively.

Experiments 8 and 9 were done in the laboratory, under dry kata cooling power of about 6, during the night and the early morning, the usual routine being reversed—*i.e.*, the subject slept during the day. The subject felt very sleepy at night although he had slept well during the day. It will be noticed that the efficiency, compared with that for the day, was not greatly altered under these conditions. We did not carry out experiments in the warm room or in the tunnel during the night.

In Table 1, it will also be observed that the respiratory quotient was raised by muscular work, as was pointed out by Benedict and Cathcart (3).

Cooling Power, Pulse Rate, and Comfort

Many experiments were done with the subject stripped to the waist. From Table 1, it will be noted that in experiments 1B and 1C the subject was clothed; these experiments may be compared with experiments 2B and 2C, respectively, in which the subject was naked to the waist. The dry kata cooling power was 5.0 in experiments 1B and 1C, and 4.2 in experiments 2B and 2C. It was thus warmer during experiments 2B and 2C. Although the subjective symptoms were much alike in both series of experiments, the pulse rate was considerably reduced by the removal of clothing, being 132 in 1B and only 110 in 2B; while it was 156 in 1C and only 140 in 2C, the rates of work being much alike. In another experiment in which the subject was clothed, the pulse was 150 after the subject had been working fourteen minutes at 514 kilogrammeters per minute; whereas, soon afterwards, when he was working stripped to the waist, the pulse was 140 at the end of fourteen minutes' work at 569 kilogrammeters per minute, the cooling power being the same in both cases. Again in experiment 3B under a dry kata cooling power of 3.9, the pulse was 120, while under a dry kata cooling power of 11.2 in experiment 7B the pulse was 108 (see Table 1), the rate of work being much the same in both. In experiment 7C the subject worked for thirty-four minutes at 503 kilogrammeters per minute, under a dry kata cooling power of 11.2, with the object of finding out how long it would take before the pulse reached 156, the figure arrived at in experiment 1C after only fourteen and three-fourths minutes' work under a dry kata cooling power of 5. The pulse having reached only 144 after the thirty-four minutes' work, experiment 7C was stopped.

In experiment 3C, the subject worked at 524 kilogrammeters per minute. When, in nine minutes, the pulse was 144, oxygen was administered for six minutes over a period of nine minutes, with three intervals of one minute for breathing ordinary air. Under the influence of oxygen the breathing, which had become excessive, was greatly relieved and the pulse was reduced to 130 per minute. The subject was still in great discomfort as he was much overheated and perspiring freely, the dry kata cooling power being only 3.9.

In Table 2, we have arranged figures for varying pulse rates and varying cooling powers under otherwise fairly constant conditions for work. It will be observed that the pulse rate varied in-

versely with the cooling power. In this table we have not included figures from the midnight experiments—*i.e.*, experiments 8 and 9 of Table 1—carried out in the laboratory, as all the other experiments were done during the ordinary daily routine and can hardly be compared, with regard to pulse, with the midnight experiments during which the subject was very sleepy and obviously possessed less tone. We did not carry out any experiments in the tunnel or in the warm room at midnight.

TABLE 2.—COOLING POWER AND PULSE IN EXPERIMENTS OF FIFTEEN MINUTES' DURATION, WITH SUBJECT C.P. CLAD IN ORDINARY CLOTHING

Pulse Rate	Kilogrammeters per Minute	Kata-Thermometer Cooling Power Dry
		millicalories per sq. cm. per second
120	515	10.8
120	509	10.3
125	507	10.9
150	514	7.5
156	507	5.0
104	399	10.9
108	406	10.3
108	407	10.8
108	407	11.2
120	414	3.9
132	408	5.0

Benedict and his co-workers and many others claim that pulse rate varies directly with the work done. We have obtained similar results only when the cooling power was kept constant. This appears to us to be a point of fundamental importance. It is obvious that the heart has much more work to do under warm conditions, with low cooling powers, than under cool conditions, with higher cooling powers (see Table 2). In the former case blood is required in the skin for sweating as well as in the muscles for work. As has already been pointed out, the efficiency of muscle as an engine does not appear to be affected during these short periods of work; it is the pulse rate and comfort that are of importance.

We have also given some attention to the amount of cooling that is required to maintain comfort at a given rate of work. We hope to carry out experiments in the tunnel covering long periods and imitating conditions for individual work as closely as possible, and thus to be able to draw up a table showing suitable cooling powers for each degree of work. The temperature during the winter months was too low—that is, the cooling power was too high—in the tunnel for such graduated experiments. Many experiments of short duration done in the tunnel under a high dry kata cooling power—25 millicalories—showed clearly that the subjects preferred to work at a fast rate so that they would not become cold. Obviously under cool conditions a worker would be willing to do more.

Our principal conclusion from the experiments here recorded is that cool conditions have great advantage over warm conditions, mainly because the heart has less work to do and bodily comfort is maintained when the cooling power is high.

We have given little attention to the body temperature; but the temperatures of the axilla and of the cheek are stated in Table 1. More accurate readings could be obtained only by placing a thermo-electric couple in the rectum. We have taken our subject's personal symptoms, comfort, and sweating as an indication of overheating.

Summary

1. Experiments are described which were made for the purpose of reinvestigating physiological reasons why workers experience greater comfort under

ideal atmospheric conditions than under ill conditions.

2. The efficiency—regarding the body as a machine—with which external work was performed during short periods by a trained subject on a bicycle ergometer was not altered by raising the dry kata-thermometer cooling power of the atmosphere from 3.9 to 11.2 millicalories per square centimeter per second.

3. The pulse rate was much reduced and bodily comfort much increased by raising the dry kata-thermometer cooling power of the atmosphere from 3.9 to 11.2. It is considered that the main factor was relief to the heart under the cool air conditions. Such relief keeps off fatigue and enables the individual to work for longer hours in comfort and with content.

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ESTIMATIONS OF MERCURY IN HATTERS' FUR AND IN FELT *

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THE following analyses were made for the purpose of discovering how much mercury is lost by vaporization or by treatment with hot water during various processes in the making of felt hats. We are indebted to the kindness of the John B. Stetson Company for the specimens of fur and felt which formed the material for this study.

After some experimentation the following method was used for the determination of mercury in carrotted fur and felt. In most cases 5 or 10 gm. of material were analyzed. The organic material was destroyed by means of nitric acid and potassium permanganate, and in general the method described by Lomholt and Christiansen (1) was followed.

Ten grams of fur were treated with 100 c.c. of concentrated nitric acid and allowed to stand overnight. In the morning 100 c.c. of water were added and the solution boiled gently, small amounts of powdered potassium permanganate being added from time to time. This was continued until all the organic material was destroyed and an excess of permanganate had been added, as shown by the presence of undissolved manganese dioxide precipitate or a permanganate color after the solution had been boiled for several minutes. The excess permanganate was reduced by boiling the solution with about 0.5 gm. of oxalic acid. At this point the solution should be a practically clear, light straw-colored fluid. Some of the excess nitric acid was removed by boiling, and the remainder nearly neutralized by the addition of solid sodium carbonate, in small amounts in order to prevent loss due to violent effervescing.

With the solution weakly but yet distinctly acid with nitric acid, the mercury was precipitated by means of hydrogen sulphide. This precipitation in nitric acid solution serves to separate the mercury from other heavy metals which may be present. There is some precipitation of sulphur but this is not excessive if too large amounts of nitric acid are avoided. This solution was filtered and the precipitate washed with hot water and dissolved in aqua regia, care being taken to remove the dissolved mercury thoroughly from the filter paper by washing it repeatedly with boiling water. This solution was boiled for about five minutes, and was then filtered in order to remove sulphur, bits of filter paper, etc.

From this point on, Volhard's (2) gravimetric determination of mercury as a sulphide was followed exactly. The solution in aqua regia was neutralized with sodium carbonate and the mercury precipitated as sulphide by boiling the solution with a slight excess of ammonium sulphide. Sodium hydroxide was then added until the solution appeared lighter colored, and as the boiling was continued more sodium hydroxide was added until the solution was perfectly clear. In this way the mercury sulphide was converted into a soluble sodium sulpho-salt, $Hg(SNa)_2$, and from this solution the mercury was reprecipitated as sulphide, in a form which is more easily filtered by the addition of an excess of solid ammonium nitrate. After the ammonia present had been removed

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by boiling, the solution was allowed to stand overnight, and was then filtered through a weighed gooch crucible, and the precipitate dried at 110° to 120° C. and weighed. (HgS x 0.8622=wt. of Hg.)

The chemical equations involved in the reprecipitation are as follows:

$$HgS+2NaOH+(NH_4)_2S \rightarrow Hg(SNa)_2+2NH_4OH$$
$$Hg(SNa)_2+2NH_4NO_3 \rightarrow 2NaNO_3+(NH_4)_2S+HgS$$

In case sulphur is present in the final precipitate of mercury sulphide, it can be removed by boiling the precipitate with sodium sulphite, which transforms the sulphur to soluble thiosulphate according to the equation

$$Na_2SO_3+S=Na_2S_2O_3$$

Although no sulphur was visibly present, the precipitates of mercury sulphide were treated with sodium sulphite in each case as a precaution against too high results due to sulphur. Good recoveries of varying amounts of mercury from pure mercury solution were made by the foregoing method, as is shown by Table 1.

TABLE 1.—RECOVERIES OF MERCURY FROM SOLUTIONS OF PURE MERCURIC CHLORIDE

Solution No.	Mercury Present *mg.*	Mercury Recovered *mg.*
1	10.0	10.2
2	10.0	10.0
3	5.0	4.9
4	20.0	19.4
5	10.0	10.1
6	10.0	9.6
7	5.0	5.1
8	20.0	20.1

The results of analyses of felt in the different stages of hat manufacture are given in Table 2. Duplicate determinations were made in every case and good agreement was obtained.

The specimens analyzed belonged to two lots, the first containing four samples, the second, two. Number 1 was carrotted fur dried in the oven for yellow carrot, dampened sufficiently to make the pelt pliable, and cut. The second specimen had been carrotted, dried in the oven, seasoned for three months in a storage room, then brushed and cut. It is evident that a decided loss of mercury occurs during this "ripening." Number 3 was fur which had gone through the same processes as specimen Number 2, and had then been blown, formed, and sized. Only a slight loss of mercury occurred during these processes, but in the course of the following stages—blocking, shaping, and pressing with hot irons—the greatest loss of mercury occurs, for Number 4, the finished hat, has only a little more than half as much mercury as the sized hat. The next two samples were from another lot, and were sent us by request because we wished to know just what was the loss of mercury in forming. Number 5 was blown fur, and Number 6 part of a cone from the forming machine. The analyses show an appreciable loss of mercury during forming.

TABLE 2.—RESULTS OF ANALYSES OF FELT IN DIFFERENT STAGES OF HAT MANUFACTURE

Specimen	Percentage of Mercury Found
1. Carrotted, dried in oven, cut when wet	2.41
2. Carrotted, dried in oven, seasoned three months	1.88
3. Sized hat	1.69
4. Finished hat	0.85
5. Blown fur	1.30
6. Cone from former	1.06

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A STUDY OF THE MORTALITY OF COAL MINERS, ENGLAND AND WALES*

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THE Mining Industry Act, 1920, Part II[1], sets up executive machinery, through pit committees, district committees and area committees, for the purpose of discussing and making recommendations (among other things) with respect to the safety, health, and welfare of the workers in connection with their work at the mines. It also transfers to the pit committees so established the management of the accommodation and the facilities for taking baths and drying clothes. In Part III this Act further provides, through a levy of 1 penny per ton of the output of each mine, a fund to be applied for purposes connected with the social well-being, recreation, and living conditions of workers in or about coal mines, and with mining education and research; it vests the duty of allocating the fund so raised in a central committee of five, now known as the Miners' Welfare Committee.

Information as to the health of miners is clearly needed for the purposes of the Act, and as a contribution to this information the following study of the mortality of coal miners has been made. The point should here be stressed, however, that entirely satisfactory information as to the health of coal miners can only be obtained by supplementing mortality statistics by information relating to invalidity and lost time.

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[1] The scheme of Part II is contingent upon agreement between masters and men; such agreement has not been reached.

The Decennial Supplements dealing with occupational mortality, issued by the Registrar General, contain information which concerns (1) coal miners in England and Wales taken as a whole; and (2) coal miners employed on the seven largest coal fields separately. Examination of the information published brings out certain points:

1. Great diversity in the death rates has been experienced on the different coal fields, ranging in 1900-1902 from a comparative figure of 675 for Nottingham and Derbyshire to one of 1,006 for Lancashire; and in 1910-1912, from 570 for Nottingham to 941 for Lancashire (see Table 1). These differences are remarkable when the environmental conditions of work and the hours of labor prevailing in the different fields are so closely identical.

2. Four causes of death are of particular importance: (*a*) phthisis; (*b*) pneumonia; (*c*) bronchitis; and (*d*) accidents. The differences between the mortality experienced from these four causes go far to account for the differences in mortality from all causes on the various fields; for instance, the difference, in 1910-1912, between the comparative mortalities experienced by the miner of Nottingham and the miner of Lancashire is 371, of which 294 are accounted for by the differences in mortality from these four causes of death.

3. A close correlation has been found to exist between the order of the coal fields arranged according to mortality and according to the results of ballots taken in 1920 and 1921. (See Table 2.) This correlation suggests that conditions of health form an unconscious impulse underlying social unrest.

These facts appeared to call for closer investigation in order to throw light, if possible, on the influences which lie at

the back of these diverse mortality rates. Application was therefore made, through the Mines Department, to Somerset House for further information, which has been courteously provided for 1910-1912. Deaths in these years, as far as available information permitted, have been grouped according to whether the deceased had worked (*a*) at the coal face, (*b*) otherwise underground, or (*c*) above ground. The information so obtained is stated in the accompanying tables, most of which have been compiled by the statistical branch of the Mines Department.

TABLE 1.—COMPARATIVE MORTALITY AMONG COAL MINERS, AGES 25-64, INCLUSIVE

Coal Field	1910-1912					1900-1902				
	All Causes	Phthisis	Pneumonia	Bronchitis	Accidents	All Causes	Phthisis	Pneumonia	Bronchitis	Accidents
Nottinghamshire[1] ...	570	53	40	25	66	675	64	52	49	80
Derbyshire[1]	591	70	34	39	73					
Northumberland and Durham	635	70	54	33	83	763	84	54	41	105
Staffordshire	717	74	70	61	109	846	66	71	104	118
Yorkshire	758	81	69	45	117	783	88	71	67	99
Monmouthshire and South Wales	777	70	69	66	131	951	93	108	104	169
Lancashire	941	107	100	88	183	1,006	96	149	113	131
All coal fields.....	727	76	64	51	118	885	89	86	79	123
Occupied and retired males.....	790	142	66	38	47	1,004	187	92	58	58

[1] Nottinghamshire and Derbyshire were grouped together previous to 1910-1912.

Mortality from All Causes

Examination of the standardized death rates set forth in Table 5 brings out certain points of interest with regard to the occupational grouping.

Workers at the Face.—The Lancashire worker stands at the top of the list, holding this position from age 20 to age 65; Staffordshire comes second; Northumberland and Durham third; and Yorkshire fourth. The Monmouthshire and South Wales district, coming last but one, is notably out of the position accorded to it in Table 1.

TABLE 2.—MORTALITY AND UNREST AMONG COAL MINERS

Coal Field[1]	Comparative Mortality 1910-1912 Due to					Percentage of Miners Polling That Voted	
	Respiratory Diseases			Accidents	All Causes	For Strike August, 1920	Against Resuming Work June, 1921
	Phthisis	Bronchitis	Pneumonia				
Nottinghamshire	53	25	40	66	570	55.1	53.7
Derbyshire	70	39	34	73	591	71.8	52.7
Northumberland and Durham	70	33	54	83	635	69.9	66.7
Yorkshire[2]	81	45	69	117	758	51.1	65.3
Monmouthshire and South Wales	70	66	69	131	774	77.9	73.0
Lancashire	107	88	100	183	941	90.6	89.6

[1] Staffordshire, although its mortality is given by the Registrar General, is excluded because the figures regarding the votes on this field were not available.

[2] A strike of six weeks' duration occurred on this field alone in 1919, which was considered to affect the ballot of 1920. When Yorkshire started even with the other fields after the strike in 1920, the ballot figures of 1921 placed this field close to the position ascribed to it by mortality data.

TABLE 3.—NUMBER OF MALES EMPLOYED AT COAL MINES IN ENGLAND AND WALES IN 1911 (INCLUDING RETIRED COLLIERY WORKERS) CLASSIFIED ACCORDING TO AGE AND WORKING POSITION

District	Age Group								
	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75 and Over	Total 15 Years and Over
				(a) Workers at the Face					
Northumberland and Durham	2,188	13,322	31,430	22,360	13,028	6,127	3,146	1,092	92,693
Lancashire	2,399	6,831	16,937	13,770	9,216	4,564	1,692	348	55,757
Yorkshire	2,993	11,087	25,890	20,139	11,533	5,697	1,970	373	79,682
Derbyshire	2,364	6,248	11,497	8,301	4,793	2,532	967	213	36,915
Nottinghamshire ...	1,750	4,178	7,903	5,763	3,339	1,688	623	143	25,387
Staffordshire	1,611	5,013	10,647	8,181	5,152	2,810	1,231	313	34,958
Monmouthshire and South Wales	27,099	23,297	36,738	26,565	13,849	5,849	2,019	453	135,869
Other districts.....	3,589	7,915	14,936	10,887	6,307	3,394	1,534	459	49,021
England and Wales (all districts)....	43,993	77,891	155,978	115,966	67,217	32,661	13,182	3,394	510,282
				(b) Other Workers below Ground					
Northumberland and Durham	29,098	13,360	12,169	10,533	8,484	6,310	2,063	165	82,182
Lancashire	9,480	6,766	7,211	5,058	3,336	1,753	529	58	34,191
Yorkshire	16,456	7,001	6,855	4,583	2,743	1,427	481	55	39,601
Derbyshire	6,641	1,458	1,542	1,305	881	528	153	11	12,519
Nottinghamshire ...	4,009	884	1,025	850	584	370	105	13	7,840
Staffordshire	6,027	2,629	2,427	1,875	1,269	721	244	32	15,224
Monmouthshire and South Wales	4,450	8,338	17,829	13,382	7,693	3,773	1,135	109	56,709
Other districts.....	5,815	2,573	2,941	2,433	1,647	1,041	377	60	16,887
England and Wales (all districts)....	81,976	43,009	51,999	40,019	26,637	15,923	5,087	503	265,153
				(c) Workers above Ground					
Northumberland and Durham	5,279	3,074	3,996	2,845	2,317	1,772	798	104	20,185
Lancashire	1,898	1,230	2,016	1,834	1,480	1,127	455	45	10,085
Yorkshire	2,853	1,773	3,056	2,453	1,828	1,190	510	53	13,716
Derbyshire	1,355	891	1,366	1,181	882	685	349	47	6,756
Nottinghamshire ...	859	581	904	777	667	485	224	43	4,540
Staffordshire	1,445	827	1,274	1,156	939	734	333	46	6,754
Monmouthshire and South Wales	1,582	1,173	3,887	3,281	2,394	1,477	644	90	15,128
Other districts.....	1,924	1,031	1,482	1,305	1,124	884	412	70	8,232
England and Wales Total (*a*) (*b*) (*c*)	17,195	11,180	17,981	14,832	11,631	8,354	3,725	498	85,396
No. per 1,000.....	143,164	132,080	225,958	170,817	105,485	56,938	21,994	4,395	860,831
	166	154	262	198	123	66	26	5	1,000

TABLE 4.—NUMBER OF DEATHS AMONG MALES EMPLOYED AT COAL MINES IN ENGLAND AND WALES DURING THE YEARS 1910 TO 1912 (INCLUDING THOSE RETIRED FROM WORK AT DEATH), CLASSIFIED ACCORDING TO AGE AT DEATH AND WORKING POSITION

District	Age Group								
	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75 and Over	Total 15 Years and Over
				(a) Workers at the Face					
Northumberland and Durham	70	174	395	439	508	697	858	545	3,686
Lancashire	16	91	319	365	464	606	588	270	2,719
Yorkshire	32	106	322	425	470	597	632	301	2,885
Derbyshire	22	53	120	139	161	219	289	145	1,148
Nottinghamshire ...	15	30	79	90	111	124	134	82	665
Staffordshire	19	55	149	185	234	303	431	245	1,621
Monmouthshire and South Wales	193	214	374	468	514	579	567	228	3,137
Other districts.....	61	113	257	249	251	339	466	366	2,102
England and Wales (all districts)....	428	836	2,015	2,360	2,713	3,464	3,965	2,182	17,963
				(b) Other Workers below Ground					
Northumberland and Durham	242	104	116	154	198	319	323	178	1,634
Lancashire	153	123	143	128	148	152	78	32	957
Yorkshire	173	120	103	95	93	115	81	35	815
Derbyshire	59	13	11	16	21	28	31	24	203
Nottinghamshire ...	27	9	11	12	18	26	26	14	143
Staffordshire	46	31	17	25	34	28	27	12	220
Monmouthshire and South Wales	62	122	325	364	370	400	303	95	2,041
Other districts.....	28	17	20	17	34	45	45	33	239
England and Wales (all districts)....	790	539	746	811	916	1,113	914	423	6,252
				(c) Workers above Ground					
Northumberland and Durham	45	41	47	50	70	93	127	83	556
Lancashire	12	16	37	30	56	98	72	31	352
Yorkshire	32	26	39	44	69	96	100	32	438
Derbyshire	14	7	15	15	22	36	47	32	188
Nottinghamshire ...	2	9	5	9	20	27	35	27	134
Staffordshire	9	7	13	15	21	40	33	22	160
Monmouthshire and South Wales	19	24	48	88	96	129	93	46	543
Other districts.....	11	11	14	13	21	40	43	46	199
England and Wales (all districts)....	144	141	218	264	375	559	550	319	2,570

TABLE 5.—MEAN ANNUAL DEATH RATE AMONG COAL MINERS IN ENGLAND AND WALES, AGED 15 YEARS AND OVER, PER 1,000 LIVING (INCLUDING THOSE OCCUPIED AND RETIRED FROM WORK) DURING THE YEARS 1910 TO 1912, FROM ALL CAUSES, ACCORDING TO AGE AT DEATH AND WORKING POSITION [1]

District	Age Group								15 Years and Over	
	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75 and Over	Crude Death Rate	Standardized Death Rate
(a) Workers at the Face										
Northumberland and Durham	10.66	4.35	4.19	6.54	13.00	37.92	90.91	166.36	13.26	12.13
Lancashire	2.22	4.44	6.28	8.84	16.78	44.26	115.84	258.62	16.26	13.74
Yorkshire	3.56	3.19	4.15	7.03	13.58	34.93	106.94	268.99	12.07	11.66
Derbyshire	3.10	2.83	3.48	5.58	11.20	28.83	99.62	226.92	10.37	9.97
Nottinghamshire	2.86	2.39	3.33	5.21	11.08	24.49	71.70	191.14	8.73	8.55
Staffordshire	3.93	3.66	4.66	7.54	15.14	35.94	116.71	260.92	15.46	12.50
Monmouthshire and South Wales	2.37	3.06	3.39	5.87	12.37	33.00	93.61	167.77	7.70	9.89
Other districts	5.67	4.76	5.74	7.62	13.27	33.29	101.26	265.80	14.30	12.48
England and Wales (all districts)	3.24	3.58	4.31	6.78	13.45	35.35	100.26	214.30	11.73	11.23
(b) Other Workers below Ground										
Northumberland and Durham	2.77	2.59	3.18	4.87	7.78	16.85	52.19	359.60	6.63	7.88
Lancashire	5.38	6.06	6.61	8.44	14.79	28.90	49.15	183.91	9.33	11.15
Yorkshire	3.50	5.71	5.01	6.91	11.30	26.86	56.13	212.12	6.86	9.82
Derbyshire	2.96	2.97	2.38	4.09	7.95	17.68	67.54	727.27	5.41	9.92
Nottinghamshire	2.24	3.39	3.58	4.71	10.27	23.42	82.54	358.97	6.08	9.51
Staffordshire	2.54	3.93	2.33	4.44	8.93	12.94	36.89	125.00	4.82	6.05
Monmouthshire and South Wales	4.64	4.88	6.08	9.07	16.03	35.34	88.99	290.52	12.00	12.98
Other districts	1.60	2.20	2.27	2.33	6.80	14.41	39.78	183.33	4.72	5.40
England and Wales (all districts)	3.21	4.18	4.78	6.76	11.46	23.30	59.89	280.32	7.86	9.67
(c) Workers above Ground										
Northumberland and Durham	2.84	4.45	3.92	5.86	10.07	17.49	53.05	206.03	9.18	8.45
Lancashire	2.11	4.34	6.12	5.45	12.61	28.99	52.75	229.03	11.63	9.69
Yorkshire	3.74	4.89	4.25	5.98	12.58	26.89	65.36	201.26	10.64	9.70
Derbyshire	3.44	2.62	3.66	4.23	8.31	17.52	44.89	226.95	9.28	7.25
Nottinghamshire	0.78	5.16	1.84	3.86	10.00	18.56	52.08	209.30	9.84	7.03
Staffordshire	2.08	2.82	3.40	4.33	7.45	18.17	33.03	159.42	7.90	6.30
Monmouthshire and South Wales	4.00	4.51	4.12	8.94	13.37	29.11	48.14	170.37	11.96	9.88
Other districts	1.91	3.56	3.15	3.32	6.23	15.08	34.80	219.05	8.06	6.11
England and Wales (all districts)	2.79	4.20	4.04	5.93	10.75	22.30	49.22	213.52	10.03	8.48

[1]For the purpose of standardization, the age distribution of the coal miners in each district and occupation has been assumed to be identical with that of all coal miners in all occupations in England and Wales.

Others below Ground.—For this group, throughout the period of working life, Monmouthshire and South Wales are found at the top of the list, holding this premier place except for the age periods up to 34 years, for which Lancashire leads. Lancashire easily holds the second place, while Staffordshire comes last.

Workers above Ground.—The information for this group is probably least reliable. The "occupational" classification of the Census of Population involves the omission of particular classes of colliery workpeople from the scope of the inquiry—*e.g.*, clerks, bricklayers, carpenters, fitters, blacksmiths, enginemen, etc. Comparison with the results of the "industrial" classification introduced into the Census of Population in 1911 shows that 82,000 workers of 15 years of age and over were recorded under such headings as those referred to above. For this reason the mortality rates for workers above ground need to be accepted with caution.

Taking the data as they stand, the Monmouthshire and South Wales district is found at the top, followed by Yorkshire and Lancashire; Staffordshire again comes last.

Possible Influences.—The inclusion of deaths from accidents might be suspected to control the order observed, but reference to the data of Table 7 shows that what has been said above for the death rates from all causes applies with but little modification to the standardized death rates from all causes exclusive of accidents.

The unenviable position held by Lancashire for each occupational group suggests that conditions apart from mining may be materially affecting the death rate. Reference to the general mortality of the districts gives some support to this suggestion.

The death rates from all causes and from phthisis, for males and females, are stated for the districts in Table 6. The death rates from all causes among males show a tendency to agree with the order of Table 1; but the tendency is less pronounced when the death rates from phthisis alone are considered.

Since the number of miners in some counties, such as Glamorgan, might be held to influence considerably the mortality among males, the mortality among females may, perhaps, be taken as a more useful measure of local influences, such as climate and density of population. The death rate from all causes among females is found to be highest in

TABLE 6.—DEATH RATE OF GENERAL POPULATION (1901-1910)

County	Death Rate per 1,000 Living			
	All Causes		Phthisis	
	Males	Females	Males	Females
Derbyshire	15.52	13.48	0.66	0.50
Nottinghamshire	16.46	14.48	0.66	0.55
South Wales	18.18[1]	15.92[1]	0.66[1]	0.68[1]
Monmouthshire	16.77	15.11	0.53	0.54
Staffordshire	17.76	15.28	0.72	0.54
Northumberland	18.59	16.23	1.00	0.84
Yorkshire, West Riding	18.27	15.45	0.76	0.55
Durham	18.63	16.65	0.88	0.83
Lancashire	20.64	17.44	0.94	0.67
England and Wales	16.60	13.95	0.78	0.58

[1] This relates to Glamorgan only where the bulk of the South Wales coal field, outside Monmouth, lies.

TABLE 7.—MEAN ANNUAL DEATH RATE PER 1,000 COAL MINERS AND WALES, CLASSIFIED ACCORDING

A. Crude Death Rates

District	Phthisis, Bronchitis and Pneumonia	Accidents	Other Diseases	Total	Total Exclusive of Accidents
		(a) Workers at the Face			
Northumberland and Durham	2.90	1.39	8.97	13.26	11.87
Lancashire	5.06	2.17	9.03	16.26	14.09
Yorkshire	3.24	1.20	7.63	12.07	10.87
Derbyshire	2.50	0.95	6.92	10.37	9.42
Nottinghamshire ...	2.03	0.98	5.72	8.73	7.75
Staffordshire	4.25	1.43	9.78	15.46	14.03
Monmouthshire and South Wales	2.11	1.17	4.42	7.70	6.53
Other districts.....	3.46	2.52	8.32	14.30	11.78
England and Wales	3.04	1.45	7.24	11.73	10.28
		(b) Other Workers below Ground			
Northumberland and Durham	1.53	0.98	4.12	6.63	5.65
Lancashire	2.29	3.40	3.64	9.33	5.93
Yorkshire	1.43	2.27	3.16	6.86	4.59
Derbyshire	1.01	1.44	2.96	5.41	3.97
Nottinghamshire ...	1.70	0.77	3.61	6.08	5.31
Staffordshire	1.03	1.69	2.10	4.82	3.13
Monmouthshire and South Wales	2.85	2.87	6.28	12.00	9.13
Other districts.....	1.01	0.99	2.72	4.72	3.75
England and Wales	1.81	1.95	4.10	7.86	5.91
		(c) Workers above Ground			
Northumberland and Durham	2.50	0.68	6.00	9.18	8.50
Lancashire	3.64	1.22	6.77	11.63	10.41
Yorkshire	2.59	1.17	6.88	10.64	9.47
Derbyshire	2.46	0.59	6.23	9.28	8.69
Nottinghamshire ...	2.86	0.22	6.76	9.84	9.62
Staffordshire	2.12	1.14	4.64	7.90	6.76
Monmouthshire and South Wales	2.78	1.43	7.75	11.96	10.53
Other districts.....	2.03	0.36	5.67	8.06	7.70
England and Wales	2.64	0.93	6.46	10.03	9.10

[1] For the purpose of standardization, the age distribution of the coal that of coal miners in all occupations in England and Wales.

15 YEARS OF AGE AND OVER LIVING IN 1910 TO 1912 IN ENGLAND TO DISTRICT AND CAUSE OF DEATH

B. Standardized Death Rates[1]

Phthisis, Bronchitis and Pneumonia	Accidents	Other Diseases	Total	Total Exclusive of Accidents	District
		(a) Workers at the Face			
2.80	1.50	7.83	12.13	10.63	Northumberland and Durham
4.30	1.90	7.54	13.74	11.84	Lancashire
3.15	1.06	7.45	11.66	10.60	Yorkshire
2.46	0.90	6.61	9.97	9.07	Derbyshire
2.04	0.96	5.55	8.55	7.59	Nottinghamshire
3.50	1.39	7.61	12.50	11.11	Staffordshire
2.76	1.23	5.90	9.89	8.66	Monmouthshire and South Wales
3.07	2.53	7.88	12.48	9.95	Other districts
2.93	1.42	6.88	11.23	9.81	England and Wales
		(b) Other Workers below Ground			
1.74	0.90	5.24	7.88	6.98	Northumberland and Durham
2.93	3.46	4.76	11.15	7.69	Lancashire
1.90	2.67	5.25	9.82	7.15	Yorkshire
2.16	1.57	6.19	9.92	8.35	Derbyshire
2.91	0.59	6.01	9.51	8.92	Nottinghamshire
1.30	1.72	3.03	6.05	4.33	Staffordshire
3.00	2.92	7.06	12.98	10.06	Monmouthshire and South Wales
1.11	1.13	3.16	5.40	4.27	Other districts
2.21	2.03	5.43	9.67	7.64	England and Wales
		(c) Workers above Ground			
2.40	0.62	5.43	8.45	7.83	Northumberland and Durham
3.04	1.11	5.54	9.69	8.58	Lancashire
2.51	1.10	6.09	9.70	8.60	Yorkshire
2.00	0.60	4.65	7.25	6.65	Derbyshire
2.31	0.21	4.51	7.03	6.82	Nottinghamshire
1.68	1.00	3.62	6.30	5.30	Staffordshire
2.34	1.37	6.17	9.88	8.51	Monmouthshire and South Wales
1.62	0.37	4.12	6.11	5.74	Other districts
2.34	0.86	5.28	8.48	7.62	England and Wales

miners in each district and occupation has been assumed to be identical with

Lancashire, and lowest in Derby and Nottingham; thus the position of these counties is in agreement with the order of Table 1. The magnitude of the differences between the highest and the lowest death rates is far less than it is in Table 1, however, while the order of the other counties in no way conforms to that order. The death rates from phthisis among females exhibit no similarity with the order of Table 1.

The conclusion seems fair that local conditions must be held to contribute something to the differences in mortality rates found to exist among coal miners, but that inquiry must be made within the industry to ascertain why these differences are so accentuated.

The mortality experienced within the industry from the four causes of death already referred to, distributed according to coal field and occupation of workers, is stated in Table 7. Consideration follows of the facts which emerge.

Phthisis

The incidence of phthisis among coal miners, not only in Great Britain but in other countries, is lower than that found in other occupations, with the exception of agriculture. This fact was particularly noted by Wainwright and Nichols who carried out certain experiments in which they exposed guinea-pigs for about two months to the inhalation of coal dust, and then injected a culture of tubercle bacilli into them. Such anthracosed animals are stated to have developed "extensive tuberculosis of the abdominal viscera, and of the glands round the tracheal injection, *but the lungs were free;*" while control animals are stated to have developed "extensive tuberculosis of the lungs and abdominal viscera." Such facts have been instanced to support the claim that coal dust in some way protects against phthisis. Certainly the data in Table 1 are in support of the observation that coal miners as a class experience a low mortality rate from phthisis, but some explanation must be sought for differences in prevalence of the disease on the various fields, such as, for instance, a comparative mortality figure of 64 in 1900-1902 for Nottingham and Derbyshire and of 96 for Lancashire, and of 53 in 1910-1912 for Nottingham and of 107 for Lancashire.

Distribution by Occupation

Should coal dust possess the power claimed for it, workers at the coal face might be expected to experience a lower mortality from phthisis than other workers underground, and others underground a lower mortality than those employed above ground.

All Coal Miners.—The mortality data set forth in Table 8, however, do not justify this anticipation. Here throughout life the mortality from phthisis for men working at the coal face is found to be higher than for others below ground, and, except for ages 20 to 34 inclusive, higher than for those working above ground. Workers above ground, on the other hand, up to age 55, suffer rather more than others below ground. These data do not support the supposition that coal dust protects the workers against phthisis.

The Separate Coal Fields.—The number of deaths due to each cause occurring on each coal field when distributed according to age and occupation is rather too small to justify reliance upon each death rate stated in the tables which follow, but the general trend can be traced. A further table (Table 9) is added in which the comparative mortality for ages 25 to 64, inclusive, is stated,

TABLE 8.—MEAN ANNUAL DEATH RATE OF COAL MINERS FROM PHTHISIS[1]

District	Age Group								15 Years and Over	
	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75 and Over	Crude Death Rate	Standardized Death Rate
(a) Workers at the Face										
Northumberland and Durham	1.98	1.18	1.00	1.04	1.02	2.01	1.38	0.31	1.13	1.27
Lancashire	0.83	0.59	0.91	1.94	2.42	2.63	1.97	0.96	1.54	1.38
Yorkshire	1.11	0.75	0.72	1.19	1.82	2.34	2.88	– –	1.18	1.78
Derbyshire	1.13	0.85	0.87	0.88	1.39	1.71	1.38	– –	1.02	1.04
Nottinghamshire ...	0.95	0.80	0.80	0.35	0.80	0.99	– –	– –	0.70	0.72
Staffordshire	1.45	0.80	1.19	1.10	1.75	1.07	1.35	1.06	1.20	1.22
Monmouthshire and South Wales	0.30	0.66	0.45	0.85	1.35	1.60	1.49	– –	0.69	0.75
Other districts.....	1.67	0.84	1.27	1.26	1.58	0.98	1.09	1.45	1.24	1.28
England and Wales (all districts)....	0.69	0.80	0.83	1.11	1.54	1.82	1.59	0.49	1.05	1.03
(b) Other Workers below Ground										
Northumberland and Durham	0.46	0.85	0.79	0.82	0.75	0.58	0.48	– –	0.66	0.72
Lancashire	0.28	0.54	1.02	0.79	1.40	1.33	0.63	– –	0.73	0.83
Yorkshire	0.67	0.86	0.68	0.51	0.73	0.47	0.69	– –	0.68	0.66
Derbyshire	0.40	0.23	0.22	0.26	1.14	1.26	– –	– –	0.43	0.43
Nottinghamshire ...	0.42	0.38	1.63	0.39	0.57	2.70	– –	– –	0.68	0.88
Staffordshire	0.33	0.63	0.27	0.71	0.26	0.46	– –	– –	0.42	0.43
Monmouthshire and South Wales	0.15	0.32	0.97	1.00	1.13	1.77	0.88	– –	0.89	0.81
Other districts.....	0.46	0.26	0.45	0.41	0.40	0.32	– –	– –	0.39	0.39
England and Wales (all districts)....	0.45	0.62	0.83	0.78	0.90	0.98	0.52	– –	0.68	0.73
(c) Workers above Ground										
Northumberland and Durham	0.95	1.95	1.17	1.05	1.01	0.19	– –	– –	1.06	1.11
Lancashire	1.05	1.90	0.99	0.91	1.35	0.59	– –	– –	1.06	1.11
Yorkshire	0.23	2.82	1.09	0.54	0.91	1.12	– –	– –	0.97	1.05
Derbyshire	0.74	0.75	0.98	0.56	1.13	0.49	– –	– –	0.74	0.78
Nottinghamshire ...	0.39	2.29	0.74	– –	– –	2.06	– –	– –	0.73	0.75
Staffordshire	– –	0.81	0.78	– –	0.71	0.91	1.00	– –	0.49	0.50
Monmouthshire and South Wales	0.21	0.38	0.51	2.03	1.11	1.13	1.04	– –	0.97	0.87
Other districts.....	0.35	0.97	0.90	1.02	0.30	0.38	1.62	– –	0.69	0.75
England and Wales (all districts)....	0.58	1.58	0.91	0.99	0.92	0.76	0.45	– –	0.91	0.95

[1] For the purpose of standardization, the age distribution of the coal miners in each district and occupation has been assumed to be identical with that of all coal miners in all occupations in England and Wales.

i.e., for the period of life when occupational influence may be expected to be established and when productivity is most pronounced—the period which the Registrar General considers as the most useful for comparative purposes.

The tendency for men at the face to suffer more from phthisis than others below ground is found to hold good throughout life, and for each field (except Nottingham and South Wales); the tendency is most marked, 1.22 as compared with 0.43, for Staffordshire, and Yorkshire, 1.78 as compared with 0.66, for the field where the phthisis mortality is highest. Nottingham and Monmouthshire and South Wales present exceptions in that workers at the face suffer less from phthisis than others below ground and than those above ground; indeed, on these fields the standardized death rates from phthisis for workers at all ages at the face are less than on any field.

TABLE 9.—COMPARATIVE MORTALITY FROM PHTHISIS AMONG COAL MINERS, AGED 25-64, CLASSIFIED ACCORDING TO COAL FIELDS AND WORKING POSITION, FOR THE PERIOD 1910-1912

Coal Field	Occupational Group: Workers at Face	Others below Ground	Workers above Ground
Northumberland and Durham....	81	55	69
Lancashire	125	77	71
Yorkshire	92	44	64
Derbyshire	77	40	59
Nottinghamshire..	49	85	39
Staffordshire	89	29	39
Monmouthshire and So. Wales..	64	79	81
England and Wales	85	60	65

With a disease like phthisis, which is more prevalent at some ages than at others, the distribution of the disease according to age must be considered. In Yorkshire, which stands at the top of the list, workers above ground suffer more up to the age of 35. In Lancashire, which comes second, the position resembles that of Yorkshire. In Northumberland and Durham, which comes third, those at the face do not suffer more until after age 54. In Staffordshire, which comes fourth, those at the face suffer more throughout life. In Derbyshire the tendency is for those at the face to suffer more through life, but the data for this field and for Nottinghamshire, where the reverse holds good, are too few to rely upon. In Monmouthshire and South Wales the position is unusual; up to age 24 workers at the face lead, then for ages 25 to 44, inclusive, workers below ground lead, and finally for ages 45 and over workers at the face again lead.

Generally on all the fields the tendency is for workers at the face, during the latter half of their working life, to suffer markedly more from phthisis than do others employed in the mining industry. Evidence points to the presence of some cumulative adverse influence which especially affects workers at the face.

Pneumonia

The range of comparative mortalities due to pneumonia on the different fields, stated in Table 1, is even wider than that for phthisis; but here, unlike the mortality from phthisis, the mortality from pneumonia among coal miners in 1910-1912, on four fields, exceeded the standard set by occupied and retired males, and in 1900-1902 it exceeded the standard on two fields. Apparently some influence is present on some fields, noticeably Lancashire, but absent on others, which predisposes to pneumonia.

TABLE 10.—MEAN ANNUAL DEATH RATE OF COAL MINERS FROM PNEUMONIA[1]

District	Age Group								15 Years and Over	
	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75 and Over	Crude Death Rate	Standardized Death Rate
(a) Workers at the Face										
Northumberland and Durham	0.91	0.23	0.36	0.57	1.10	2.77	4.03	2.44	0.82	0.83
Lancashire	0.14	0.39	0.79	0.87	2.06	3.29	6.50	8.62	1.37	1.15
Yorkshire	0.11	0.27	0.32	0.68	1.42	2.87	6.60	5.36	0.92	0.84
Derbyshire	0.14	0.16	0.26	0.40	0.56	1.32	4.83	– –	0.50	0.48
Nottinghamshire ...	0.38	0.08	0.21	0.58	0.50	1.18	7.49	2.33	0.58	0.59
Staffordshire	– –	0.13	0.50	0.77	1.68	2.85	3.79	4.26	1.00	0.82
Monmouthshire and South Wales	0.15	0.29	0.35	0.59	1.08	2.79	5.28	4.42	0.61	0.75
Other districts.....	0.19	0.55	0.38	0.37	1.22	2.16	4.35	2.18	0.76	0.71
England and Wales (all districts)....	0.19	0.28	0.40	0.61	1.27	2.61	5.16	3.63	0.81	0.78
(b) Other Workers below Ground										
Northumberland and Durham	0.19	0.12	0.14	0.35	0.90	1.58	3.07	4.04	0.45	0.47
Lancashire	0.42	0.44	0.60	1.38	2.20	3.23	3.78	5.75	0.98	1.18
Yorkshire	0.20	0.33	0.49	0.80	1.34	1.40	3.47	– –	0.51	0.72
Derbyshire	0.10	0.23	0.22	0.51	0.38	0.63	4.36	30.30	0.29	0.56
Nottinghamshire ...	0.17	0.75	– –	1.57	– –	1.80	6.35	25.64	0.55	0.87
Staffordshire	0.17	0.25	0.27	0.53	1.31	0.46	1.37	– –	0.37	0.47
Monmouthshire and South Wales	0.30	0.44	0.60	0.77	1.43	2.74	5.58	3.06	0.95	0.94
Other districts.....	– –	0.13	0.11	0.14	0.61	1.60	0.88	5.56	0.26	0.31
England and Wales (all districts)....	0.20	0.29	0.41	0.70	1.23	1.95	3.60	4.64	0.61	0.72
(c) Workers above Ground										
Northumberland and Durham	0.25	– –	0.42	0.47	1.15	1.69	2.51	12.82	0.66	0.63
Lancashire	0.18	0.54	0.50	0.55	0.90	3.85	5.86	14.81	1.19	0.94
Yorkshire	0.70	– –	0.44	0.54	1.82	2.24	3.27	6.29	0.92	0.83
Derbyshire	0.25	0.37	0.49	– –	0.38	0.97	3.82	– –	0.54	0.44
Nottinghamshire ...	– –	1.15	0.74	0.43	1.00	1.37	1.49	– –	0.73	0.71
Staffordshire	0.46	– –	0.26	0.87	0.71	1.36	2.00	14.49	0.74	0.62
Monmouthshire and South Wales	– –	0.94	0.60	1.12	1.11	2.03	2.07	3.70	0.99	0.86
Other districts.....	0.17	– –	0.22	– –	0.59	1.89	4.05	– –	0.57	0.39
England and Wales (all districts)....	0.29	0.30	0.46	0.58	1.06	2.03	2.95	6.69	0.81	0.70

[1] For the purpose of standardization, the age distribution of the coal miners in each district and occupation has been assumed to be identical with that of all coal miners in all occupations in England and Wales.

TABLE 11. — COMPARATIVE MORTALITY FROM PNEUMONIA AMONG COAL MINERS, AGED 25-64, CLASSIFIED ACCORDING TO COAL FIELDS AND WORKING POSITION, FOR THE PERIOD 1910-1912

Coal Field	Occupational Group: Workers at Face	Others below Ground	Workers above Ground
Northumberland and Durham ...	64	39	54
Lancashire	101	107	74
Yorkshire	71	62	71
Derbyshire	36	28	28
Nottinghamshire....	36	49	56
Staffordshire	81	41	48
Monmouthshire and So. Wales..	64	79	74
England and Wales	67	62	59

Distribution by Occupation

All Coal Miners.—The mortality from pneumonia among miners distributed according to occupation is given in Tables 10 and 11. Here other workers below ground are found to suffer slightly more than men at the face, up to age 44, after which age men at the face suffer more. Workers above ground in early life, up to age 34, suffer more than either group of underground workers, but for later age periods the mortality is higher among the underground workers.

Separate Coal Fields. — Lancashire stands at the top of each occupational group; at all ages men at the face and below ground suffer nearly equally, but among men at the face there is an excess of the disease after age 65; in the mid-period of life both underground groups suffer more than workers above ground.

In Staffordshire men at the face suffer more than the other two occupational groups, throughout life (except for the unreliable period, ages 75 and over).

In Yorkshire there is a close similarity between the prevalence of the disease among men at the face and the prevalence among those above ground; and throughout life both groups tend to suffer more than others working below ground.

In Monmouthshire and South Wales the tendency is for pneumonia to be more prevalent throughout life among others below ground than among men at the face, and among those above ground. These four fields experience more pneumonia than the standard population.

In Northumberland and Durham men at the face, up to age 64, suffer more than either of the other groups; and those above ground suffer more than others below ground.

In Nottingham and Derby, which stand lowest, men at the face suffer less than others below ground.

The general tendency on the fields where pneumonia is high is for men at the face to suffer more than others below ground; this tendency is reversed in Nottingham and in Monmouthshire and South Wales, the fields where phthisis is also unusual in that it is more prevalent among others below ground than among those at the face.

Bronchitis

As in the case of pneumonia, data in Table 1 disclose a wide range in the mortality from bronchitis among coal miners. In 1900-1902 this mortality on four fields exceeded the standard set by occupied and retired males, and in 1910-1912 this standard was exceeded on five fields. Here, just as in the case of pneumonia, there is evidence of some influence being present on certain fields, noticeably Lancashire, which predisposes to bronchitis.

Distribution by Occupation

All Coal Miners.—The mortality from bronchitis among miners distributed

TABLE 12.—MEAN ANNUAL DEATH RATE OF COAL MINERS FROM BRONCHITIS [1]

District	Age Group								15 Years and Over	
	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75 and Over	Crude Death Rate	Standardized Death Rate
(a) Workers at the Face										
Northumberland and Durham	– –	– –	0.02	0.15	0.38	3.32	11.76	19.84	0.95	0.71
Lancashire	0.14	– –	0.06	0.36	1.48	8.03	26.60	52.68	2.15	1.78
Yorkshire	– –	0.03	0.01	0.13	0.64	4.10	20.14	45.58	1.14	1.13
Derbyshire	– –	– –	0.03	0.08	0.56	3.29	17.92	32.86	0.98	0.94
Nottinghamshire	– –	– –	– –	0.06	0.20	1.97	11.24	53.61	0.75	0.73
Staffordshire	– –	– –	0.06	0.16	1.23	4.98	27.89	47.92	2.05	1.49
Monmouthshire and South Wales	– –	0.01	0.03	0.15	0.87	5.70	22.29	31.64	0.81	1.26
Other districts	– –	– –	0.02	0.15	0.37	3.73	16.95	62.45	1.46	1.08
England and Wales (all districts)	0.01	0.01	0.03	0.16	0.74	4.65	18.89	37.22	1.18	1.12
(b) Other Workers below Ground										
Northumberland and Durham	– –	0.07	0.03	0.09	0.47	1.43	5.98	40.40	0.42	0.55
Lancashire	0.04	– –	0.14	0.13	0.70	3.42	15.12	28.74	0.58	0.92
Yorkshire	– –	– –	– –	0.15	0.61	1.64	8.32	18.18	0.24	0.52
Derbyshire	– –	– –	– –	0.26	0.38	0.63	4.36	181.82	0.29	1.16
Nottinghamshire	– –	– –	– –	– –	– –	0.90	12.70	153.85	0.47	1.16
Staffordshire	– –	– –	– –	– –	0.26	1.39	6.83	20.83	0.24	0.41
Monmouthshire and South Wales	– –	0.04	0.04	0.30	1.13	4.59	17.62	55.05	1.01	1.25
Other districts	– –	– –	– –	– –	0.61	0.96	6.19	27.78	0.36	0.44
England and Wales (all districts)	– –	0.03	0.04	0.17	0.69	2.34	9.89	43.07	0.52	0.76
(c) Workers above Ground										
Northumberland and Durham	– –	– –	– –	0.35	1.01	1.88	7.10	32.05	0.78	0.66
Lancashire	– –	0.27	– –	0.55	0.90	4.14	11.72	29.63	1.39	0.99
Yorkshire	– –	– –	– –	0.27	0.91	1.40	7.19	37.74	0.70	0.63
Derbyshire	– –	– –	0.24	0.28	– –	3.41	7.64	49.65	1.18	0.79
Nottinghamshire	– –	– –	– –	0.43	1.00	2.75	10.42	38.76	1.40	0.85
Staffordshire	– –	– –	– –	– –	0.35	5.90	2.00	14.49	0.89	0.56
Monmouthshire and South Wales	0.21	– –	0.17	0.10	0.70	2.48	5.69	22.22	0.82	0.61
Other districts	– –	– –	– –	0.26	0.30	1.51	4.85	33.33	0.77	0.48
England and Wales (all districts)	0.02	0.03	0.06	0.27	0.72	2.71	6.98	31.46	0.92	0.68

[1] For the purpose of standardization, the age distribution of the coal miners in each district and occupation has been assumed to be identical with that of all coal miners in all occupations in England and Wales.

according to occupation and age is stated in Tables 12 and 13. Men above ground are found to suffer more from bronchitis in early life, men at the face suffer more after age 45, and others below ground after age 65.

Separate Coal Fields.—In Lancashire where the bronchitis mortality is highest, the relative prevalence of the disease by occupation is the same as for all coal miners. In Monmouthshire and South Wales others below ground suffer most up to age 54, after which men at the face suffer most. Men above ground suffer rather less than either group throughout life. In Staffordshire men at the face suffer most, workers above ground coming second. In Yorkshire the same is true. The prevalence of bronchitis on these four fields is above that among the standard population. For Derbyshire the tendency up to age 75 is for men at the face to suffer most from the disease; and on this field, except at the terminal age period, men above ground suffer more than others below ground. In Nottinghamshire the tendency is for men above ground to suffer more throughout life than those underground, but for both underground groups to catch up late in life.

TABLE 13. — COMPARATIVE MORTALITY FROM BRONCHITIS AMONG COAL MINERS, AGED 25-64, CLASSIFIED ACCORDING TO COAL FIELDS AND WORKING POSITION, FOR THE PERIOD 1910-1912

Coal Field	Occupational Group: Workers at Face	Others below Ground	Workers above Ground
Northumberland and Durham ..	42	24	40
Lancashire	108	50	64
Yorkshire	51	28	32
Derbyshire	43	17	45
Nottinghamshire .	23	9	50
Staffordshire	71	17	62
Monmouthshire and South Wales ...	72	68	40
England and Wales	60	36	45

The general tendency is for bronchitis, especially when present in excess, to affect men at the face particularly later in life; but here again the exceptional position of the Monmouthshire and South Wales field is notable.

Accidents

The mortality rate from accidents among coal miners is exactly opposite to that from phthisis in being above the standard for occupied and retired males on all the coal fields, but it resembles the mortalities from phthisis, pneumonia, and bronchitis in showing a marked diversity on the various fields and in being highest where these diseases are most prevalent, and *vice versa*. In 1910-1912 the position of the coal fields arranged in order of merit according to the mortality rate from either pneumonia or accidents was exactly the same, and in 1900-1902 there was also a close similarity.

Distribution by Occupation

All Coal Miners.—The mortality distributed by occupation is stated in Tables 14 and 15. Others below ground are found to suffer the highest mortality from accidents throughout life; men employed at the coal face come next; and those above ground come last.

Separate Coal Fields.—In Lancashire, where the accident rate for ages 25 to 64, like the mortality rate from phthisis, pneumonia, and bronchitis, is the highest on the coal fields, others below ground have a higher mortality throughout life than men at the face, and men at the face a higher mortality than workers above ground. In Monmouthshire and South Wales the position with

TABLE 14.—MEAN ANNUAL DEATH RATE OF COAL MINERS FROM ACCIDENT[1]

District	Age Group								15 Years and Over	
	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75 and Over	Crude Death Rate	Standardized Death Rate
(a) Workers at the Face										
Northumberland and Durham	2.13	1.18	1.08	1.15	1.69	2.45	2.65	3.05	1.39	1.50
Lancashire	0.14	2.10	2.24	2.06	2.46	2.78	2.17	2.87	2.17	1.90
Yorkshire	0.22	0.57	1.33	1.11	1.39	2.05	2.03	0.89	1.20	1.06
Derbyshire	0.42	0.80	0.67	1.16	0.97	1.58	2.07	4.69	0.95	0.90
Nottinghamshire	0.57	0.56	0.67	1.27	0.90	2.57	2.14	2.33	0.98	0.96
Staffordshire	1.24	1.20	1.03	1.43	2.01	2.14	1.08	5.32	1.43	1.39
Monmouthshire and South Wales	1.06	0.82	1.00	1.36	1.40	2.34	2.31	1.47	1.17	1.23
Other districts	2.69	2.15	2.39	2.60	2.85	2.06	4.35	2.90	2.52	2.53
England and Wales (all districts)	1.09	1.10	1.30	1.46	1.73	2.28	2.43	2.85	1.45	1.42
(b) Other Workers below Ground										
Northumberland and Durham	1.23	0.57	0.71	0.95	1.10	1.27	0.65	– –	0.98	0.90
Lancashire	3.23	3.30	3.10	3.23	4.10	5.13	2.52	11.49	3.40	3.46
Yorkshire	1.48	2.43	2.82	3.05	3.65	2.57	3.47	– –	2.27	2.67
Derbyshire	1.25	1.37	1.08	2.04	2.65	1.26	2.18	– –	1.44	1.57
Nottinghamshire	0.91	1.13	– –	0.39	0.57	1.80	– –	– –	0.77	0.59
Staffordshire	1.55	1.52	0.96	1.42	3.41	4.16	– –	– –	1.69	1.72
Monmouthshire and South Wales	2.92	2.76	2.32	2.84	3.29	4.24	4.70	6.12	2.87	2.92
Other districts	0.40	0.91	1.02	1.10	1.62	1.92	4.42	– –	0.99	1.13
England and Wales (all districts)	1.55	1.84	1.90	2.17	2.57	2.66	2.29	2.65	1.95	2.03
(c) Workers above Ground										
Northumberland and Durham	0.76	0.43	0.50	0.47	0.72	1.13	1.67	– –	0.68	0.62
Lancashire	0.35	0.54	0.99	0.73	2.70	2.96	– –	7.41	1.22	1.11
Yorkshire	1.40	0.19	0.65	1.36	1.28	1.96	1.96	12.58	1.17	1.10
Derbyshire	0.98	0.37	0.98	0.28	– –	0.97	– –	– –	0.59	0.60
Nottinghamshire	– –	0.57	– –	0.43	– –	– –	1.49	– –	0.22	0.21
Staffordshire	0.92	0.81	0.78	0.58	1.42	1.82	4.00	– –	1.14	1.00
Monmouthshire and South Wales	1.69	1.32	0.60	1.63	0.70	2.71	4.66	3.70	1.43	1.37
Other districts	0.17	0.65	0.45	– –	0.59	0.38	– –	4.77	0.36	0.37
England and Wales (all districts)	0.83	0.60	0.63	0.85	1.00	1.68	1.88	3.35	0.93	0.86

[1] For the purpose of standardization, the age distribution of the coal miners in each district and occupation has been assumed to be identical with that of all coal miners in all occupations in England and Wales.

TABLE 15. — COMPARATIVE MORTALITY FROM ACCIDENTS AMONG COAL MINERS, AGED 25-64, CLASSIFIED ACCORDING TO COAL FIELDS AND WORKING POSITION, FOR THE PERIOD 1910-1912

Coal Field	Occupational Group: Workers at Face	Others below Ground	Workers above Ground
Northumberland and Durham ..	99	66	45
Lancashire	164	256	109
Yorkshire	98	215	83
Derbyshire	71	121	41
Nottinghamshire..	82	33	9
Staffordshire	107	144	70
Monmouthshire and So. Wales..	97	209	85
England and Wales	112	158	65

regard to those underground is the same, but workers above ground tend to suffer a higher mortality at nearly every age than do men at the face. In Yorkshire the usual position is found, others below ground experiencing more fatal accidents throughout life than men at the face, and men at the face (except after age 75) more than workers above ground. In Staffordshire and in Derbyshire the same is true. In Durham and Northumberland and in Nottinghamshire men at the face are exceptional in heading the list throughout life; others below ground come next; and workers above ground last.

Mortality data for accidents for the years 1910-1912 cannot be discussed without reference to the occurrence of two mining disasters. One, which took place in 1910 at Hulton in Lancashire, caused 344 deaths, and thus raised the total of fatal accidents on that field to 460, as compared with 110 in 1911, and 129 in 1912; the explosion occurred while coal getting was in progress and affected all underground workers alike. The other disaster, which occurred in 1912 at Cadeby in Yorkshire, caused 88 deaths, and thus raised the total of fatal accidents on that field to 247 for that year, as compared with 166 for 1911, and 173 for 1910; this explosion did not affect men at the face as repairing work only was in progress at the time. These two disasters affect the position of the fields concerned as may be seen by calculating the annual accident rate, apart from explosions, for the four fields with the highest rates.

Coal Field	Total Number Employed, 1911[2]	Fatal Accidents (Explosions Excluded), 1910-1912[2]: Number	Annual Death Rate per 1,000
Lancashire	102,894	354	1.15
Yorkshire	148,026	486	1.09
Monmouthshire and So. Wales	220,815	923	1.39
Staffordshire ..	56,270	217	1.29

The general tendency is for others below ground to suffer a higher mortality from accidents than men at the face, and for both groups of underground workers to suffer a higher mortality than workers above ground. But on two fields, where the accident rate is low—Durham and Northumberland, and Nottingham—others below ground suffer less than men at the face; these two fields have already been noted as standing below the average for all coal fields for each of the respiratory diseases.

[2] The data here are estimates made by the Home Office of (*a*) the number employed and (*b*) the deaths attributable to mining accidents.

(To be Continued)

MEDICAL EXAMINATION OF EMPLOYEES*

D. A. Coles, M.D.

Chairman of the Medical Committee of the Industrial Welfare Society, London

The general consensus of opinion (lay and medical) endorses the sound axiom that, whenever possible, each employee should be medically examined before being accepted for any kind of work. In all large works this is essential—in the small one it is extremely advisable—in the interests of the employee, the employer, and the community in general. This axiom being accepted, it follows that a form to be filled in should be provided. What the exact nature of this form should be can be determined only after mature consideration, founded on experience and corrected by revision.

The following rules should be adopted in the preparation of forms for medical examination to be filled in by the physician examining the employee:

A. The examination must be strictly confidential, and must not be filed with the general dossier or record of the worker. The forms should, therefore, be headed *Private and Confidential.*

B. The examination should be made by a physician specially qualified for this particular work. For example, the senior surgeon of a large hospital may be as unfitted to decide between functional and organic disease of the heart, as the examining physician would be to perform a complicated abdominal operation. The one is a specialist and aims at knowing everything about something; the other should know something about everything.

C. The forms should be uniform: *(a)* for purpose of comparison; *(b)* for facility in recording statistics; *(c)* for saving time; and *(d)* for economy in their production.

D. The forms should be simple. What is not relevant may always be neglected, but what is omitted in the form may be forgotten. It ensures greater accuracy and prevents the omission of important details.

E. They should be printed: *(a)* on one side only; *(b)* on good paper to avoid destruction; *(c)* in small, clear type, providing ample room for answers; *(d)* on thin paper for reduplication. Two copies are always required, frequently more.

F. Different forms should be printed on differently colored paper.

G. Different forms should be provided for different circumstances: *(a) New employees:* (1) men, (2) women, (3) children —(1) and (2) may appear on the same form, though this is generally not advisable; *(b) Accidents:* (1) original examination, (2) continuation, *i.e.*, subsequent examinations.

It is important that a copy of each report should be filed for ready reference by the physician. At each subsequent examination he should have before him all the worker's previous medical reports.

The following specimen health report is submitted for comment, suggestion, and discussion. As already indicated, it should be headed *Private and Confidential.* Below these words should appear the name of the firm, corporation, or society.

HEALTH REPORT

Part I

Name (of employee). Surname followed by other names. The address may be inserted if necessary. Generally, however, it is unnecessary and therefore should not cumber the report, as it will always appear in his other papers.

Wages No. Sometimes called "Works No.," "Stage No.," etc.

C.P. No.—*i.e.*, Co-partnership.

1. Suitability for this occupation. I have placed this immediately after the worker's name for the convenience of the manager. It is often the only answer at which he looks. It may also be used for suitability for co-partnership, old-age pension, etc. It may be answered "Yes," "No," "Postponed," "For light work only," etc.

2. Age on last birthday. A birth certificate should be procured if possible. In my experience at a military hospital, also at the re-survey board of the Ministry of Pensions, as the pensions representative on the Dispersal Board at a Dispersal Hospital in London, and as medical officer to the Ministry of Munitions, I found that there were two ages—the official age and the real age. In industry it is equally important, as the following incident shows. I once said to a man, "Your birth certificate shows you to be 34; you gave your age last year as 29." "Well, sir," said the

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man, "the job was open only to men under 30."

3. Height.
4. Weight.
5. Occupation.
6. Duration of service with this firm (present and previous). If previously employed, mention the reason why he left the company—*e.g.*, slackness of work, ill health, etc.
7. Time lost through illness during the past five years.
8. Date of previous medical reports (health, accident, special, etc.). I attach much importance to this question.

Part II

9. Family history.
10. Previous maladies.
11. Military history—*e.g.*, date of joining the service, together with category; gunshot wounds, illness, accident, etc., during military service, date of demobilization, with category; pension.
12. Sight.
13. Hearing.
14. Teeth.
15. Rupture.
16. General health. Heart, lungs, etc.
17. General remarks.

There are numerous other questions which may appear on a medical report, some of which are advisable, such as, for instance, a urine examination. (There are obvious difficulties in making this test universal.) Other questions which are often included are inadvisable. An example of this type of question is the following: "Is the worker moderate in the use of alcohol?" Not once in ten thousand times does a physician answer this in the negative. The question is nearly always put to the examinee on a life assurance form, and it is always answered in the affirmative, even by the habitual drunkard.

The above is only suggested as a skeleton form to encourage comment. The questions are divided into two parts, the first eight, except under the head of suitability, being of a general character, the remainder of a medical character, and of a specially confidential nature. In all cases where the answers to the questions are on the worker's authority only, the word "stated" should be inserted.

I shall be pleased to consider correspondence containing suggestions and criticisms with reference to the proposed form. Letters should be sent to me at the following address: The Industrial Welfare Society, 51, Palace Street, Westminster.

LABOUR RECORDS IN FACTORIES*

G. M. Broughton, M.A., O.B.E.

Adviser, Labour Bureau, Government of India

The subject of record-keeping in factories is now coming into prominence. The necessity of recording facts relating to output, amount of material used and power consumed, in order that the costs of manufacture may be estimated, has been recognized for some time past. The important part, however, that the human element plays in the enhancement or the lowering of the costs of production has not yet received the same attention. In many factories one finds that practically no records relating to the employees are kept. Almost the only fact that appears to be noted is the employee's name in the wages book. Consequently, in many cases of absence, as even the address of the worker is not known, there are no means of ascertaining whether his absence is merely temporary or whether he has no intention of returning. In this way thousands of workers drift in and out of employment without the factory management having any definite knowledge of the causes influencing this ebb and flow. This condition of affairs is not peculiar to India; it holds good to-day in England among many firms. The reason for this in England is that, in ordinary seasons, the supply of labour is plentiful: in India, on the other hand, though labour is generally difficult to obtain, yet, in view of its nominal cheapness, managers have felt it unnecessary to give special attention to this question.

There are, however, many obvious advantages that immediately accrue as a result of installing a sound system of record-keeping. The writer is taking this opportunity of drawing attention to some of them—and hopes also to answer some of the objections generally brought forward by the opponents of record-keeping. After having dealt with both aspects of this question, it is proposed to make some suggestions regarding record forms. It is not intended to imply that it will be possible for all firms to adopt exactly the same forms. Each firm will necessarily have to make alterations and modifications to adapt the forms to its own requirements. The model forms given here should, however, serve as a useful guide.

A difficulty with which managers are usually confronted is connected with the selection and maintenance of a healthy and efficient working staff. Very little, however, appears to be done directly to achieve this end, beyond the provision of good working conditions. In England some employment superintendents succeed, by means of rough and ready tests, in eliminating applicants who are obviously unfit. Psychological tests of practical ability are, however, gradually being evolved (1) (2). Much thought is being given to this subject in America also (3) (4). In India the scarcity of labour makes selection still more difficult. There is little doubt, however, that Indian employers also would benefit by studying methods of selection. The methods now in vogue are admittedly unsatisfactory—hereditary training and aptitude are neither available nor considered essential for employment in power factories. Owing to the chronic shortage of labour, the employer is apt to engage all persons offering themselves, and very often this important work is left to a contractor who has no interest in the efficiency of the labour which he supplies. The result of this haphazard procedure, or absence of method, becomes immediately evident if an estimate is made of the large proportion of workers who leave after only a few weeks. An enquiry made in England in munition and non-munition factories (5), showed that in many cases over fifty per cent. of those engaged left within the first three months of employment. The proportion is probably much larger in India. In one factory, for example, where the conditions of employment are exceptionally good, it has been calculated that there is a complete labour turn-over once every eighteen months. It will therefore be worth while to take steps to ascertain the causes governing this constant change among the workers. Men are trained, but leave before they have given an economic return for their training. They have to be replaced by fresh, unskilled workers. Output, in consequence, is considerably below the level it would otherwise reach. The workers on their part also suffer, as they seldom attain sufficient skill to earn the highest wages.

As a first step, the writer suggests that a member of the factory staff should be entrusted with the definite task of discovering

*Reprinted from the *Journal of Indian Industries and Labour*, Feb., 1922, 2, Part 1, 64-76.

the reasons why the workers leave. He should also be asked to keep a separate record for each worker. If, as a result, it is found that many are leaving because they have no aptitude or liking for the work, or because they are lacking in physique, then the need for a careful preliminary selection will be at once apparent. If, on the other hand, the men or women leave because they are dissatisfied with any features in the working conditions, then it may be possible to rectify them and so to lessen the exodus from the factory.

Again, the time-keeping in the factory may be unsatisfactory. No steps can be taken to improve it until the cause is discovered. It may be due to faulty transport facilities, to long hours of work and short spells of rest inducing avoidable fatigue, or to hours of work not adapted to the habits and customs of the workers. No doubt, all these matters do receive the constant attention of all competent managers, but it seems to the writer that the best way of discovering, in a systematic manner, the main causes at work is to introduce some machinery whereby the reasons of lateness and bad time-keeping are not only recorded but also studied.

Further, there may be an undue amount of sickness among the workers in one particular department or in the factory as a whole. It ought to be easy to ascertain the causes from properly maintained dispensary records. In her visits to mills and factories the writer has frequently been introduced to the medical staffs. They are almost invariably interested in their duties and anxious to lessen the incidence of sickness in the works. Their time is, however, as a rule, fully occupied with the clinical part of the work and the records relating thereto. Sufficient use is not made of the data thus available. In order, however, that these data may be easily utilized the doctors should be consulted and a standard system of classification should be introduced. The trade association concerned might then appoint a medical man to study the records with a view to discovering what the more general ailments are and their causes, or assistance would probably be given, if desired, by medical experts belonging to the government of India or to the provincial governments.

Besides sickness, accidents also play a large part in lowering output. In this connection the writer wishes to draw attention to the "Safety First" movement (6), which is gradually spreading throughout the more important industries in various countries. It makes an appeal specially to the intelligence of the workmen. Factory managers are naturally concerned in the reduction of the accident rate, but, apart from all question of heavy compensation, where the law of the particular country specifically provides for it, they recognize how much work can be seriously hampered by preventable accidents. The best course to pursue is to start a vigorous "Safety First" campaign, and at the same time to maintain a careful record of accidents in the factory.

The employer, the writer has found, frequently objects to starting a system of record-keeping on the ground of expense. Enough has been said to show that any money spent in this direction will bring a high return in efficiency and consequently in output. Factory managers in England who have adopted a sound system of record-keeping readily testify to the truth of this statement. On the other hand the workers may object to what may seem at first sight to be inquisitorial enquiries. It ought not to be difficult, however, for a sympathetic manager to explain to his workers that the new system is really designed for their benefit. Furthermore, the many difficulties under which labour often struggles inarticulately should come to light if the records are utilized carefully and systematically. At present, in a great many cases, practically the only action that a worker takes, if he is unable to adapt himself to factory conditions, is to leave the factory. A study of the reasons of leaving, if recorded, should give the employer some insight into features found unsatisfactory by the workers, and he would then be in a position to eliminate or to reduce them.

Regarding the form in which the records should be maintained, the writer suggests that, at the outset, they should be as simple as possible. Later, they can be elaborated if necessary. The forms appended to this article are based on those published by the Industrial Fatigue Research Board in England (5, Appendix II). They have, however, been modified and simplified in such a way as to make them suitable for use in Indian factories.

To obtain all the necessary details regarding engagement and dismissal, a simple employment form kept on a card (see Form 1) is all that is required. When an estimate of the labour turn-over has to be made, all the relevant facts can be easily extracted from these cards. This information should then be summarized in tabular form (Form 2).

Lost time may be compiled for each individual, or, if this involves too much clerical labour, departmental returns may at first

suffice. In any case the form kept, whether for the individual or the department, does not differ very much (see Forms 3 and 4).

For purposes of classification of cases of sickness the medical officer will find it necessary to adopt some system. One that was found useful by the Ministry of Munitions is to be found in Report No. 13 of the Industrial Fatigue Research Board to which reference has already been made, and also at the foot of the sickness table (see Form 5). This, again, may be kept separately for each individual or may be maintained departmentally (see Form 6). Its utility will be much greater if arrangements can be made for a separate card to be kept for each individual.

With regard to accidents, experience has shown in England (7) that some individuals are more liable to accidents than others employed on exactly the same work. It is, therefore, obviously advantageous to keep, if possible, individual accident records. Similarly, some departments have a higher accident rate than others. The individual records should, therefore, be summarized departmentally from time to time in tabular form. In accordance with rules framed under the Indian Factories Act and the Indian Mines Act, managers already have to submit accident reports. Much additional labour will not therefore be involved. The writer has attempted to give a model form which will be in conformity with existing regulations (see Form 7).

The writer will be very glad to answer any inquiries from interested readers.

It will also be very helpful if firms who already have experience in this matter will kindly communicate their views either to the writer or to the Editor of this JOURNAL.

BIBLIOGRAPHY

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3. Münsterberg, H.: Psychology and Industrial Efficiency. New York, Houghton Mifflin Co., 1913.
4. Kelly, R. W.: Hiring the Worker. New York, The Engineering Magazine Co., 1918.
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RECORD FORMS

FORM 1.—EMPLOYMENT CARD*

Name	Sex	Caste	District of Domicile	Other Circumstances
Address				
Names of near relatives in factory	Age			

Date of Engagement	Department	Rate of Pay	Date of Leaving	Reason
	Job			

*This form is most conveniently kept in the shape of a folder: all the other records relating to the same individual can then be placed in it. In cases where men return after having left, some factories may find it desirable to enter the new particulars on the same card. This can be done if, in printing, sufficient space is left in the lower portion of the card.

FORM 2.—LABOUR TURN-OVER

Month	Total Nos. Employed	Total Nos. Leaving	Left of Own Accord					Discharged				
			Ill Health	Dissatisfied	Leaving District	Other Reasons	Ill Health	Unsatisfactory	Incompetent	Reduction of Staff	Percentage Rate of Loss
January											
February											
March											
April											
May											
June											
TOTAL											
July											
August											
September											
October											
November											
December											
TOTAL											
Year											
TOTAL											

FORM 3.—EMPLOYEES' ATTENDANCE REGISTER*

Name of factory..... *Month*..... *Year*.....

Department:..*Nos. employed during month*...*Total hours worked*.... { (*a*) *Ordinary*..*Total hrs. lost*..... (*b*) *Overtime*.. } { (*a*) *Personal reasons* (*b*) *Sickness*..... }

Name	Age	Sex	Caste	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan Muhammad	29	M.	Muhdn	F	F	F	FO	H	A	½	F	F	FO_2	FO_4	FO_2	½	S	S	S	S	S	H	½	F	F	F	F	F	F	H				

*F=full day's work or actual number of hours. A=absent. S=absent sick; if due to accident mark SA. ½, etc.=proportion of full day's work. F+O=full day + overtime. FO_2, etc.=2 hours of overtime. H=holiday.

FORM 4.—MONTHLY RETURN OF TIME LOST*

Name of factory *Total no. of employees*

Name of department *Total no. of hours worked* *Year*

Month	Total Number of Hours Lost				Total Time Lost	Total Possible Time	Percentage of Time Lost
	Illness	Accident	Personal Reasons	Other Reasons			
January							
February							
March							
April							
May							
June							
July							
August							
September							
October							
November							
December							

*This is summarized from the departmental returns.

FORM 5.—DISPENSARY RECORD*

Name of factory

Medical record, 1922

Name of Worker	Age	Sex	Caste	Date off Duty	Date of Return to Duty	Occupation and No. of Room	Cause of Disability	Treatment Given
Jan Muhammad	29	M	Muhdn.	Jan. 14, 1922	Jan. 20, 1922	Spinnel No. 1 room	Whitlow following injury to finger at work.	

*For purposes of quick tabulation the "Cause of Disability" may be summarized as follows: The exact diagnosis should be entered under the appropriate heading: (1) respiratory tract; (2) digestive tract; (3) circulatory system; (4) central nervous system; (5) special sense organs; (6) locomotive system; (7) skin; (8) influenza; (9) malaria and other fevers; (10) infectious diseases; (11) various; (12) accident and septic cases. For suggestions for filling in the diagnosis see Form 6.

FORM 6.—MONTHLY RETURN OF SICKNESS CASES REPORTED IN DISPENSARY*

A. Men
B. Women
C. Children

Month	Nos. Employed	Respiratory Tract	Digestive Tract	Circulatory System	Central Nervous System	Special Sense Organs	Locomotive System	Skin	Influenza	Malaria and Other Fevers	Infectious Diseases	Various	Accident and Septic Cases	Total No. of Sickness Cases	Percentage Rate of Sickness
January ...															
February ..															
March															
April															
May															
June															
July															
August ..															
Septembe...															
October ..															
November...															
December.....															

*The exact diagnosis should be entered under the appropriate heading. As suggestions for filling in a diagnosis in the appropriate category, the following examples are given: (1) Respiratory tract, *e.g.*, bronchitis, pulmonary tuberculosis, pneumonia, adenoids. (2) Digestive tract, *e.g.*, indigestion, tonsillitis, appendicitis, diarrhoea, colitis, gastric ulcer, gastric carcinoma, dysentery. (3) Circulatory system, *e.g.*, anaemia, morbus cordis, angina pectoris, varicose veins. (4) Central nervous system, *e.g.*, debility, tabes, neurasthenia. (5) Special sense organs, *e.g.*, astigmatism, cataract, otorrhoea. (6) Locomotive system, *e.g.*, rheumatism, sciatica, lumbago, chronic arthritis. (7) Skin, *e.g.*, scabies, industrial dermatitis. (8) Infectious diseases, such as cholera, small-pox, plague. (9) Various, *e.g.*, nephritis, measles, salpingitis, lead poisoning.

FORM 7.—EMPLOYEE'S ACCIDENT RECORD*

1. Branch of department in which accident occurred .....
2. Name of injured person.....Check No.....
   Address.....
   (*a*) Sex... (*b*) Age... (*c*) Caste (*d*) Occupation...
3. Date and hour of accident.....
4. Hour at which employee started work on day of accident.....
5. Cause of accident.....
   If caused by machinery:
   (1) Give name of machine and part causing accident .....
   (2) State whether it was moved by mechanical power at the time.....
6. State exactly what injured person was doing at the time.....
7. Describe fully nature and extent of injuries (*i.e.*, part affected).....
8. Suggestions for prevention of similar accidents .....
9. Witness's name ..... No. .....
10. Foreman .....
11. First aid by.....
12. Other treatment by.....

*Heads 2, 3, 5, 7, and 12 are required to be kept in Section 37 of the Indian Factories Act, 1911.

BOOKS RECEIVED

Books received are acknowledged in this column, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

THE PRINCIPLES AND PRACTICE OF NURSING. By *Bertha Harmer*, B.Sc. (Columbia University), R. N. Instructor of Theory and Associate Instructor of Practical Nursing, St. Luke's Hospital Training School for Nurses, New York: Formerly Instructor of Theory and of Practical Nursing, and Supervisor of Nurses, The Toronto General Hospital Training School for Nurses, Toronto, Canada. Cloth. Pp. 695 with preface, table of contents and index. New York: The Macmillan Company, 1922.

OBSTETRICAL NURSING. By *Carolyn Conant Van Blarcom*, R.N. Formerly Assistant Superintendent and Instructor in Obstetrical Nursing and the Care of Infants and Children at the Johns Hopkins Hospital Training School for Nurses: Author of "The Midwife in England." Cloth. Pp. 558 with table of contents, illustrations, charts and index. New York: The Macmillan Company, 1922.

NEW GROWTHS AND CANCER. By *Simeon B. Wolbach*, M.D., Shattuck Professor of Pathological Anatomy in Harvard University. Cloth. Pp. 53 with illustrations. Cambridge: Harvard University Press, 1922.

X-RAY DOSAGE IN TREATMENT AND RADIOGRAPHY. By *William Daniel Witherbee*, M.D., Radiotherapist Presbyterian Hospital, New York; formerly Roentgenologist Rockefeller Institute; and *John Remer*, M.D., Radiotherapist New York Hospital, New York; Consulting Radiotherapist United Hospital, Port Chester. Cloth. Pp. 87 with preface, New York: The Macmillan Company, 1922.

JOINT MEETINGS OF INDUSTRIAL HYGIENE SECTION OF THE AMERICAN PUBLIC HEALTH ASSOCIATION AND THE OHIO ASSOCIATION OF INDUSTRIAL PHYSICIANS

CLEVELAND, OHIO, OCTOBER 17 AND 18, 1922

Program

Tuesday, October 17—9:30 A. M.

Hotel Statler

1. Business Meeting of Ohio Association of Industrial Physicians.

2. PRESIDENT'S ADDRESS. *Sydney S. McCurdy, M.D.*

3. CAUSES OF ABSENTEEISM AMONG STORE WORKERS. *Charles A. Swan, M.D.*, Medical Director, Halle Brothers Company, Cleveland, Ohio.

Discussion by *A. B. Emmons, 2d, M.D.*, Executive Secretary, Harvard Mercantile Health Work, Boston, Mass.

4. COMPUTATION OF PARTIAL LOSS OF VISION AND HEARING. *William M. Mehl, M.D.*, Buffalo, N. Y.

Discussion by *Webb P. Chamberlain, M.D.*, Cleveland, Ohio.

5. MENTAL HYGIENE IN INDUSTRY. *Frederick W. Dershimer, M.D.*, National Lamp Works, Cleveland, Ohio.

Discussion by *A. G. Cranch, M.D.*, Medical Director, National Carbon Company, Cleveland, Ohio.

6. HEAT HAZARDS IN INDUSTRY. *G. H. McKinstry, M.D.*, Medical Director, Spang, Chalfant & Company, Pittsburgh, Pa.

Discussion by *S. H. Johnson, M,D.*, Carnegie Steel Company, Pittsburgh, Pa.

Wednesday, October 18, 9:30 A. M.

Nela Park, Laboratory of Applied Science, Room 117

1. Business Meeting of Industrial Hygiene Section, American Public Health Association.

2. THE TUBERCULOSIS PROBLEM IN INDUSTRY. (Stereopticon illustration.) *Horace John Howk, M.D.*, Assistant Medical Director, Metropolitan Life Insurance Company; Physician in Charge, Metropolitan Life Insurance Sanatorium, Mt. McGregor, N. Y.

Discussion by *H. A. Pattison, M.D.*, Supervisor, Medical Service, National Tuberculosis Association, New York City; *James A. Britton, M.D.*, International Harvester Company, Chicago, Ill.; and *George M. Price, M.D.*, Director, The Joint Board of Sanitary Control, New York City.

3. INDUSTRIAL DERMATOSES. (Stereopticon illustration.) *Harold N. Cole, M.D.*, Associate Professor of Dermatology, Western Reserve University, Cleveland, Ohio.

Discussion by *Charles Baskin*, Akron, Ohio.

4. HEALTH EDUCATION IN INDUSTRY. (Stereopticon and motion picture illustration.) *Ralph W. Elliott, M.D.*, Manager, Medical Department, National Lamp Works of General Electric Company, Cleveland, Ohio.

Wednesday Afternoon—2:30 P. M.

1. LIGHTING AND VISION, WITH SPECIAL EMPHASIS ON SCHOOL-LIGHTING AND HOME-LIGHTING. (Followed by lighting demonstrations.) *M. Luckiesh*, Director of Applied Science, Nela Research Laboratories.

2. INDUSTRIAL LIGHTING. (Followed by demonstrations.) *Ward Harrison*, Illuminating Engineer, National Lamp Works.